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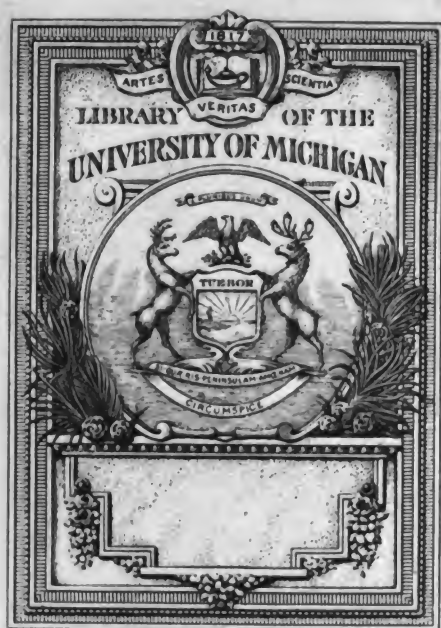
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Lectures on science, philosophy and art, 1907-1908

Columbia
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LECTURES ON SCIENCE, PHILOSOPHY AND ART
1907-1908

COLUMBIA UNIVERSITY LECTURES

LECTURES
ON
SCIENCE, PHILOSOPHY
AND ART

1907-1908



New York
THE COLUMBIA UNIVERSITY PRESS
1908

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MATHEMATICS

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY,
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
OCTOBER 16, 1907**



MATHEMATICS

BY

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New York

THE COLUMBIA UNIVERSITY PRESS

1907

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Set up, and published November, 1907.



MATHEMATICS

IN the early part of the last century a philosophic French mathematician, addressing himself to the question of the perfectibility of scientific doctrines, expressed the opinion that one may not imagine the last word has been said of a given theory so long as it can not by a brief explanation be made clear to the man of the street. Doubtless that conception of doctrinal perfectibility, taken literally, can never be realized. For doubtless, just as there exist now, so in the future there will abound, even in greater and greater variety and on a vaster and vaster scale, deep-laid and high-towering scientific doctrines that, in respect to their infinitude of detail and in their remoter parts and more recondite structure, shall not be intelligible to any but such as concentrate their life upon them. And so the noble dream of Gergonne can never literally come true. Nevertheless, as an ideal, as a goal of aspiration, it is of the highest value, and, though in no case can it be quite attained, it yet admits in many, as I believe, of a surprisingly high degree of approximation. I do not mind frankly owning that I do not share in the feeling of those, if there be any such, who regard their special subjects as so intricate, mysterious and high, that in all their sublimer parts they are absolutely inaccessible to the profane man of merely general culture even when he is led by the hand of an expert and condescending guide. For scientific theories are, each and all of them, and they will continue to be, built upon and about

notions which, however sublimated, are nevertheless derived from common sense. These etherealized central concepts, together with their manifold bearings on the higher interests of life and general thought, can be measurably assimilated to the language of the common level from which they arose. And, in passing, I should like to express the hope that here at Columbia there may one day be established a magazine that shall have for its aim to mediate, by the help, if it may be found, of such pens as those of Huxley and Clifford, between the focal concepts and the larger aspects of the technical doctrines of the specialist, on the one hand, and the teeming curiosity, the great listening, waiting, eager, hungering consciousness of the educated thinking public on the other. Such a service, however, is not to be lightly undertaken. An hour, at all events, is hardly time enough in which to conduct an excursion even of scientific folk through the mazes of more than twenty hundred years of mathematical thought or even to express intelligibly, if one were competent, the significance of the whole in a critical estimate.

Indeed, such is the character of mathematics in its profounder depths and in its higher and remoter zones that it is well nigh impossible to convey to one who has not devoted years to its exploration a just impression of the scope and magnitude of the existing body of the science. An imagination formed by other disciplines and accustomed to the interests of another field may scarcely receive suddenly an apocalyptic vision of that infinite interior world. But how amazing and how edifying were such a revelation, if only it could be made. To tell the story of mathematics from Pythagoras and Plato to Hilbert and Lie and Poincaré; to recount and appraise the achievements of such as Euclid and Archimedes, Apollonius and Diophantus; to display and estimate the creations of Descartes and Leibniz and Newton; to dispose in genetic or-

der, to analyze, to synthesize and evaluate, the discoveries of the Bernoullis and Euler, of Desargues and Pascal and Monge and Poncelet, of Steiner and Möbius and Plücker and Staudt, of Lobatschewsky and Bolyai, of W. R. Hamilton and Grassmann, of Laplace, Lagrange and Gauss, of Boole and Cayley and Hermite and Gordan, of Bolzano and Cauchy, of Riemann and Weierstrass, of Georg Cantor and Boltzmann and Klein, of the Peirces and Schröder and Peano, of Helmholtz and Maxwell and Gibbs; to explore, and then to map for perspective beholding and contemplation, the continent of doctrine built up by these immortals, to say nothing of the countless refinements, extensions and elaborations meanwhile wrought by the genius and industry of a thousand other agents of the mathetic spirit;—to do that would indeed be to render an exceeding service to the higher intelligence of the world, but a service that would require the conjoint labors of a council of scholars for the space of many years. Even the three immense volumes of Moritz Cantor's *Geschichte der Mathematik*, though they do not aspire to the higher forms of elaborate exposition and though they are far from exhausting the material of the period traversed by them, yet conduct the narrative down only to 1758. That date, however, but marks the time when mathematics, then schooled for over a hundred eventful years in the unfolding wonders of Analytic Geometry and the Calculus and rejoicing in the possession of these the two most powerful among the instruments of human thought, had but fairly entered upon her modern career. And so fruitful have been the intervening years, so swift the march along the myriad tracks of modern analysis and geometry, so abounding and bold and fertile withal has been the creative genius of the time, that to record even briefly the discoveries and the creations since the closing date of Cantor's work would require an addition to his great volumes of a score of volumes more.

Indeed the modern developments of mathematics constitute not only one of the most impressive, but one of the most characteristic, phenomena of our age. It is a phenomenon, however, of which the boasted intelligence of a "universalized" daily press seems strangely unaware; and there is no other great human interest, whether of science or of art, regarding which the mind of the educated public is permitted to hold so many fallacious opinions and inferior estimates. The golden age of mathematics—that was not the age of Euclid, it is ours. Ours is the age in which no less than six international congresses of mathematics have been held in the course of nine years. It is in our day that more than a dozen mathematical societies contain a growing membership of over two thousand men representing the centres of scientific light throughout the great culture nations of the world. It is in our time that over five hundred scientific journals are each devoted in part, while more than two score others are devoted exclusively, to the publication of mathematics. It is in our time that the *Jahrbuch über die Fortschritte der Mathematik*, though admitting only condensed abstracts with titles, and not reporting on all the journals, has, nevertheless, grown to nearly forty huge volumes in as many years. It is in our time that as many as two thousand books and memoirs drop from the mathematical press of the world in a single year, the estimated number mounting up to fifty thousand in the last generation. Finally, to adduce yet another evidence of similar kind, it requires no less than the seven ponderous tomes of the forthcoming *Encyklopädie der Mathematischen Wissenschaften* to contain, not expositions, not demonstrations, but merely compact reports and bibliographic notices sketching developments that have taken place since the beginning of the nineteenth century. The Elements of Euclid is as small a part of mathematics as the Iliad is of literature; or as the sculpture of Phidias is of the

world's total art. Indeed if Euclid or even Descartes were to return to the abode of living men and repair to a university to resume pursuit of his favorite study, it is evident that, making due allowance for his genius and his fame, and presupposing familiarity with the modern scientific languages, he would yet be required to devote at least a year to preparation before being qualified even to begin a single strictly graduate course.

It is not, however, by such comparisons nor by statistical methods nor by any external sign whatever, but only by continued dwelling within the subtle radiance of the discipline itself, that one at length may catch the spirit and learn to estimate the abounding life of modern mathesis: oldest of the sciences, yet flourishing to-day as never before, not merely as a giant tree throwing out and aloft myriad branching arms in the upper regions of clearer light and plunging deeper and deeper root in the darker soil beneath, but rather as an immense mighty forest of such oaks, which, however, literally grow into each other so that by the junction and intercrescence of limb with limb and root with root and trunk with trunk the manifold wood becomes a single living organic growing whole.

What is this thing so marvelously vital? What does it undertake? What is its motive? What its significance? How is it related to other modes and forms and interests of the human spirit?

What is mathematics? I inquire, not about the word, but about the thing. Many have been the answers of former years, but none has approved itself as final. All of them, by nature belonging to the "literature of knowledge," have fallen under its law and "perished by supersession." Naturally conception of the science has had to grow with the growth of the science itself.

A traditional conception, still current everywhere except in critical circles, has held mathematics to be the science of

quantity or magnitude, where magnitude including multitude (with its correlate of number) as a special kind, signified whatever was "capable of increase and decrease and measurement." Measurability was the essential thing. That definition of the science was a very natural one, for magnitude did appear to be a singularly fundamental notion, not only inviting but demanding consideration at every stage and turn of life. The necessity of finding out how many and how much was the mother of counting and measurement, and mathematics, first from necessity and then from pure curiosity and joy, so occupied itself with these things that they came to seem its whole employment.

✓ Nevertheless, numerous great events of a hundred years have been absolutely decisive against that view. For one thing, the notion of *continuum*—the "Grand Continuum" as Sylvester called it—that great central supporting pillar of modern Analysis, has been constructed by Weierstrass, Dedekind, Georg Cantor and others, without any reference whatever to quantity, so that number and magnitude are not only independent, they are essentially disparate. When we attempt to correlate the two, the ordinary concept of measurement as the repeated application of a constant finite unit, undergoes such refinement and generalization through the notion of Limit or its equivalent that counting no longer avails and measurement retains scarcely a vestige of its original meaning. And when we add the further consideration that non-Euclidian geometry employs a scale in which the unit of angle and distance, though it is a constant unit, nevertheless appears from the Euclidian point of view to suffer lawful change from step to step of its application, it is seen that to retain the old words and call mathematics the science of quantity or magnitude, and measurement, is quite inept as no longer telling either what the science has actually become or what its spirit is bent upon.

Moreover, the most striking measurements, as of the volume of a planet, the growth of cells, the valency of atoms, rates of chemical change, the swiftness of thought, the penetrative power of radium emanations, are none of them done by *direct* repeated application of a unit or by any direct method whatever. They are all of them accomplished by one form or another of indirection. It was perception of this fact that led the famous philosopher and respectable mathematician, Auguste Comte, to define mathematics as "the science of indirect measurement." Here doubtless we are in presence of a finer insight and a larger view, but the thought is not yet either wide enough or deep enough. For it is obvious that there is an immense deal of admittedly mathematical activity that is not in the least concerned with measurement whether direct or indirect. Consider, for example, that splendid creation of the nineteenth century known as Projective Geometry: a boundless domain of countless fields where reals and imaginaries, finites and infinities, enter on equal terms, where the spirit delights in the artistic balance and symmetric interplay of a kind of conceptual and logical counterpoint,—an enchanted realm where thought is double and flows throughout in parallel streams. Here there is no essential concern with number or quantity or magnitude, and metric considerations are entirely absent or completely subordinate. The fact, to take a simplest example, that two points determine a line uniquely, or that the intersection of a sphere and a plane is a circle, or that any configuration whatever—the reference is here to ordinary space—presents two reciprocal aspects according as it is viewed as an ensemble of points or as a manifold of planes, is not a *metric* fact at all: it is not a fact about size or quantity or magnitude of any kind. In this domain it was *position* rather than size that seemed to some the central matter, and so it was proposed to call mathematics the science of measurement and *position*.

Even as thus expanded, the conception yet excludes many a mathematical realm of vast extent. Consider that immense class of things known as Operations. These are limitless alike in number and in kind. Now it so happens that there are many systems of operations such that any two operations of a given system, if thought as following one another, together thus produce the same effect as some other single operation of the system. Such systems are infinitely numerous and present themselves on every hand. For a simple illustration, think of the totality of possible straight motions in space. The operation of going from point *A* to point *B*, followed by the operation of going from *B* to point *C*, is equivalent to the single operation of going straight from *A* to *C*. Thus the system of such operations is a closed system: combination, *i.e.*, of any two of the operations yields a third one, not without, but within, the system. The great notion of Group, thus simply exemplified, though it had barely emerged into consciousness a hundred years ago, has meanwhile become a concept of fundamental importance and prodigious fertility, not only affording the basis of an imposing doctrine—the Theory of Groups—but therewith serving also as a bond of union, a kind of connective tissue, or rather as an immense cerebro-spinal system, uniting together a large number of widely dissimilar doctrines as organs of a single body. But—and this is the point to be noted here—the abstract operations of a group, though they are very real things, are neither magnitudes nor positions.

This way of trying to come at an adequate conception of mathematics, namely, by attempting to characterize in succession its distinct domains, or its varieties of content, or its modes of activity, in the hope of finding a common definitive mark, is not likely to prove successful. For it demands an exhaustive enumeration, not only of the fields now occupied by the science, but also of those destined to

be conquered by it in the future, and such an achievement would require a prevision that none may claim.

Fortunately there are other paths of approach that seem more promising. Everyone has observed that mathematics, whatever it may be, possesses a certain mark, namely, a degree of certainty not found elsewhere. So it is, proverbially, the exact science par excellence. Exact, no doubt, but in what sense? An excellent answer is found in a definition given about one generation ago by a distinguished American mathematician, Professor Benjamin Peirce: "Mathematics is the science which draws necessary conclusions,"—a formulation of like significance with the following fine *mot* by Professor William Benjamin Smith: "Mathematics is the universal art apodictic." These statements, though neither of them is adequate, are both of them telling approximations, at once foreshadowing and neatly summarising for popular use, the epoch-making thesis established by the creators of modern logic, namely, that mathematics is included in, and, in a profound sense, may be said to be identical with, Symbolic Logic. Observe that the emphasis falls on the quality of being "necessary," *i.e.*, correct logically, or valid formally.

But why are mathematical conclusions correct? Is it that the mathematician has a reasoning faculty essentially different in kind from that of other men? By no means. What, then, is the secret? Reflect that conclusion implies premises, that premises involve terms, that terms stand for ideas or concepts or notions, and that these latter are the ultimate material with which the spiritual architect, called the Reason, designs and builds. Here, then, one may expect to find light. The apodictic quality of mathematical thought, the correctness of its conclusions as conclusions, are due, not to any special mode of ratiocination, but to the character of the concepts with which it deals. What is that distinctive characteristic? The answer is: precision

and completeness of determination. But how comes the mathematician by such completeness? There is no mysterious trick involved: some concepts admit of such precision and completeness, others do not; the mathematician is one who deals with those that do.

The matter, however, is not quite so simple as it sounds, and I bespeak your attention to a word of caution and of further explanation. The ancient maxim, *ex nihilo nihil fit*, may well be doubted where it seems most obviously valid, namely, in the realm of matter, for it may be that matter has evolved from something else; but the maxim cannot be ultimately denied where its application is least obvious, namely, in the realm of mind, for without principia in the strictest sense, doctrine is, in the strictest sense, impossible. And when the mathematician speaks of complete determination of concepts and of rigor of demonstration, he does not mean that the undefined and the undemonstrated have been or can be entirely eliminated from the foundations of his science. He knows that such elimination is impossible; he knows, too, that it is unnecessary, for some undefinable ideas are perfectly clear and some undemonstrable propositions are perfectly precise and certain. It is in terms of such concepts that a definable notion, if it is to be mathematically available, must admit of complete determination, and in terms of such propositions that mathematical discourse secures its rigor. It is, then, of such indefinables among ideas and such indemonstrables among propositions—paradoxical as the statement may appear—that the foundations of mathematics in its ideal conception are composed; and whatever doctrine is logically constructible on such a basis is mathematics either actually or potentially. I am not asserting that the substructure herewith characterized has been brought to completion. It is on the conception of it that the accent is here designed to fall, for it is the conception as such that at once affords

to fundamental investigation a goal and a guide and furnishes the means of giving the science an adequate definition.

On the other hand, actually to realize the conception requires that the foundation to be established shall both include every element that is essential and exclude every one that is not. For a foundation that subsequently demands or allows superfoetation of hypotheses is incomplete; and one that contains the non-essential is imperfect. Of the two problems thus presented, it is the latter, the problem of exclusion, of reducing principles to a minimum, of applying Occam's Razor to the pruning away of non-essentials,—it is that problem that taxes most severely both the analytic and the constructive powers of criticism. And it is to the solution of that problem that the same critical spirit of our time, which in other fields is reconstructing theology, burning out the dross from philosophy, and working relentless transformations of thought on every hand, has directed a chief movement of modern mathematics.

Apart from its technical importance, which can scarcely be overestimated, the power, depth and comprehensiveness of the modern critical movement in mathematics, make it one of the most significant scientific phenomena of the last century. Double in respect to origin, the movement itself has been composite. One component began at the very centre of mathematical activity, while the other took its rise in what was then erroneously regarded as an alien domain, the great domain of symbolic logic.

A word as to the former component. For more than a hundred years after the inventions of Analytical Geometry and the Calculus, mathematicians may be said to have fairly rioted in applications of these instruments to physical, mechanical and geometric problems, without concerning themselves about the nicer questions of fundamental

principles, cogency, and precision. In the latter part of the eighteenth century the efforts of Euler, Lacroix and others to systematize results served to reveal in a startling way the necessity of improving foundations. Constructive work was not indeed arrested by that disclosure. On the contrary new doctrines continued to rise and old ones to expand and flourish. But a new spirit had begun to manifest itself. The science became increasingly critical as its towering edifices more and more challenged attention to their foundations. Manifest already in the work of Gauss and Lagrange, the new tendency, under the powerful impulse and leadership of Cauchy, rapidly develops into a momentous movement. The Calculus, while its instrumental efficacy is meanwhile marvelously improved, is itself advanced from the level of a tool to the rank and dignity of a science. The doctrines of the real and of the complex variable are grounded with infinite patience and care, so that, owing chiefly to the critical constructive genius of Weierstrass and his school, that stateliest of all the pure creations of the human intellect—the Modern Theory of Functions with its manifold branches—rests to-day on a basis not less certain and not less enduring than the very integers with which we count. The movement still sweeps on, not only extending to all the cardinal divisions of Analysis but, through the agencies of such as Lobatschewsky and Bolyai, Grassmann and Riemann, Cayley and Klein, Hilbert and Lie, recasting the foundations of Geometry also. And there can scarcely be a doubt that the great domains of Mechanics and Mathematical Physics are by their need destined to a like invasion.

In the light of all this criticism, mathematics came to appear as a great ensemble of theories, compendent no doubt, interpenetrating each other in a wondrous way, yet all of them distinct, each built up by logical processes on its own appropriate basis of pure hypotheses, or assumptions,

or postulates. As all the theories were thus seen to rest equally on hypothetical foundations, all were seen to be equally legitimate; and doctrines like those of Quaternions, non-Euclidian geometry and Hyperspace, for a time suspected because based on postulates not all of them traditional, speedily overcame their heretical reputations and were admitted to the circle of the lawful and orthodox.

It is one thing, however, to deal with the principal divisions of mathematics severally, underpinning each with a foundation of its own. That, broadly speaking, has been the plan and the effect of the critical movement as thus far sketched. But it is a very different and a profounder thing to underlay all the divisions at once with a single foundation, with a foundation that shall serve as a support, not merely for all the *divisions* but for something else, distinct from each and from the sum of all, namely, for the *whole*, the science itself, which they constitute. It is nothing less than that achievement which, unconsciously at first, consciously at last, has been the aim and goal of the other component of the critical movement, that component which, as already said, found its origin and its initial interest in the field of symbolic logic. The advantage of employing symbols in the investigation and exposition of the formal laws of thought is not a recent discovery. As everyone knows, symbols were thus employed to a small extent by the Stagirite himself. The advantage, however, was not pursued; because for two thousand years the eyes of logicians were blinded by the blazing genius of the "master of those that know." With the single exception of the reign of Euclid, the annals of science afford no match for the tyranny that has been exercised by the logic of Aristotle. Even the important logical researches of Leibniz and Lambert and their daring use of symbolical methods were powerless to break the spell. It was not till 1854 when George Boole, having invented an algebra to trace and illuminate the

subtle ways of reason, published his symbolical "Investigation of the Laws of Thought," that the revolution in logic really began. For, although for a time neglected by logicians and mathematicians alike, it was Boole's work that inspired and inaugurated the scientific movement now known and honored throughout the world under the name of Symbolic Logic.

It is true, the revolution has advanced in silence. The discoveries and creations of Boole's successors, of C. S. Peirce, of Schröder, of Peano and of their disciples and peers, have not been proclaimed by the daily press. Commerce and politics, gossip and sport, accident and crime, the shallow and transitory affairs of the exoteric world,—these have filled the columns and left no room to publish abroad the deep and abiding things achieved in the silence of cloistral thought. The demonstration by symbolical means of the fact that the three laws of Identity, Excluded Middle and Non-contradiction are absolutely independent, none of them being derivable from the other two; the discovery that the syllogism is not deducible from those laws but has to be postulated as an independent principle; the discovery of the astounding and significant fact that false propositions imply all propositions and that true ones, though not implying, are implied by, all; the discovery that most reasoning is not syllogistic, but is asyllogistic, in form, and that, therefore, contrary to the teaching of tradition, the class-logic of Aristotle is not adequate to all the concerns of rigorous thought; the discovery that Relations, no less than Classes, demand a logic of their own, and that a similar claim is valid in the case of Propositions: no intelligence of these events nor of the immense multitude of others which they but meagrely serve to hint and to exemplify, has been cabled round the world and spread broadcast by the flying bulletins of news. Even the scientific public, for the most part accustomed to viewing the

mind as only the instrument and not as a subject of study, has been slow to recognize the achievements of modern research in the minute anatomy of thought. Indeed it has been not uncommon for students of natural science to sneer at logic as a stale and profitless pursuit, as the barren mistress of scholastic minds. These men have not been aware of what certainly is a most profound, if indeed it be not the most significant, scientific movement of our time. In America, in England, in Germany, in France, and especially in Italy—supreme histologist of the human understanding—the deeps of mind and logical reality have been explored in our generation as never before in the history of the world. Owing to the power of the symbolic method, not only the foundations of the Aristotelian logic—the Calculus of Classes—have been recast, but side by side with that everlasting monument of Greek genius, there rise today two other structures, fit companions of the ancient edifice, namely, the Logic of Relations and the Logic of Propositions.

And what are the entities that have been found to constitute the base of that triune organon? The answer is surprising: a score or so of primitive, indemonstrable, propositions together with less than a dozen undefinable notions, called logical constants. But what is more surprising—for here we touch the goal and are enabled to enunciate what has been justly called “one of the greatest discoveries of our age”—is the fact that the basis of logic is the basis of mathematics also. Thus the two great components of the critical movement, though distinct in origin and following separate paths, are found to converge at last in the thesis: Symbolic Logic is Mathematics, Mathematics is Symbolic Logic, the twain are one.

Is it really so? Does the identity exist in fact? Is it true that so simple a unifying foundation for what has hitherto been supposed two distinct and even mutually

alien interests has been actually ascertained? The basal masonry is indeed not yet completed but the work has advanced so far that the thesis stated is beyond dispute or reasonable doubt. Primitive propositions appear to allow some freedom of choice, questions still exist regarding relative fundamentality, and statements of principles have not yet crystallized into settled and final form; but regarding the nature of the data to be assumed, the smallness of their number and their adequacy, agreement is substantial. In England, Russell and Whitehead are successfully engaged now in forging "chains of deduction" binding the cardinal matters of Analysis and Geometry to the premises of General Logic, while in Italy the *Formulaire de Mathématiques* of Peano and his school has been for some year growing into a veritable encyclopedia of mathematics wrought by the means and clad in the garb of symbol logic.

But is it not incredible that the concept of number with all its distinctions of cardinal and ordinal, fractional and whole, rational and irrational, algebraic and transcendental, real and complex, finite and infinite, and the concept of geometric space, in all its varieties of form and dimensionality, is it not incredible that mathematical ideas, surpassing in multitude the sands of the sea, should be precisely definable, each and all of them, in terms of a few logical constants, in terms, *i.e.*, of such undefinable notions as *such that*, *implication*, *denoting*, *relation*; *class*, *propositional function*, and two or three others? And is it not incredible that by means of so few as a score of premises (composed of ten principles of deduction and ten other indemonstrable propositions of a general logical nature), the entire body of mathematical doctrine can be strictly and formally deduced?

It is wonderful, indeed, but not incredible. Not incredible in a world where the mustard seed becometh a tree, not

incredible in a world where all the tints and hues of sea and land and sky are derived from three primary colors, where the harmonies and the melodies of music proceed from notes that are all of them but so many specifications of four generic marks, and where three concepts—energy, mass, motion, or mass, time, space—apparently suffice for grasping together in organic unity the mechanical phenomena of a universe.

But the thesis granted, does it not but serve to justify the cardinal contentions of the depreciators of mathematics? Does it not follow from it that the science is only a logical grind, suited only to narrow and straitened intellects content to tramp in treadmill fashion the weary rounds of deduction? Does it not follow that Schopenhauer was right in regarding mathematics as the lowest form of mental activity, and that he and our own genial and enlightened countryman, Oliver Wendell Holmes, were right in likening mathematical thought to the operations of a calculating machine? Does it not follow that Huxley's characterization of mathematics as "that study which knows nothing of observation, nothing of induction, nothing of experiment, nothing of causation," is surprisingly confirmed by fact? Does it not follow that Sir William Hamilton's famous and terrific diatribe against the science finds ample warrant in truth? Does it not follow, as the Scotch philosopher maintains, that mathematics regarded as a discipline, as a builder of mind, is inferior? That devotion to it is fatal to the development of the sensibilities and the imagination? That continued pursuit of the study leaves the mind narrow and dry, meagre and lean, disqualifying it both for practical affairs and for those large and liberal studies where moral questions intervene and judgment depends, not on nice calculation by rule, but on a wide survey and a balancing of probabilities?

The answer is, no. Those things not only do not follow

but they are not true. Every count in the indictment, whether explicit or only implied, is false. Not only that, but the opposite in each case is true. On that point there can be no doubt; authority, reason and fact, history and theory, are here in perfect accord. Let me say once for all that I am conscious of no desire to exaggerate the virtues of mathematics. I am willing to admit that mathematicians do constitute an important part of the salt of the earth. But the science is no catholicon for mental disease. There is in it no power for transforming mediocrity into genius. It cannot enrich where nature has impoverished. It makes no pretense of creating faculty where none exists, of opening springs in desert minds. "*Du bist am Ende—was du bist.*" The great mathematician, like the great poet or great naturalist or great administrator, is born. My contention shall be that where the mathetic endowment is found, there will usually be found associated with it, as essential implications in it, other endowments in generous measure, and that the appeal of the science is to the whole mind, direct no doubt to the central powers of thought, but indirectly through sympathy of all, rousing, enlarging, developing, emancipating all, so that the faculties of will, of intellect and feeling learn to respond, each in its appropriate order and degree, like the parts of an orchestra to the "urge and ardor" of its leader and lord.

As for Hamilton and Schopenhauer, those detractors need not detain us long. Indeed but for their fame and the great influence their opinions have exercised over "the ignorant mass of educated men," they ought not in this connection to be noticed at all. Of the subject on which they presumed to pronounce authoritative judgment of condemnation, they were both of them ignorant, the former well nigh proudly so, the latter unawares, but both of them, in view of their pretensions, disgracefully ignorant. Lack of knowledge, however, is but a venial sin, and English-

speaking mathematicians have been disposed to hope that Hamilton might be saved in accordance with the good old catholic doctrine of invincible ignorance. But even that hope, as we shall see, must be relinquished. In 1835 William Whewell, then fellow and tutor of Trinity College, Cambridge, published an appreciative pamphlet entitled "Thoughts on the Study of Mathematics as a Part of a Liberal Education." The author was a brilliant scholar. "Science was his forte," but "omniscience his foible," and his reputation for universal knowledge was looming large. That reputation, however, Hamilton regarded as his own prerogative. None might dispute the claim, much less share the glory of having it acknowledged on his own behalf. Whewell must be crushed. In the following year Sir William replies in the *Edinburg Review*, and such a show of learning! The reader is apparently confronted with the assembled opinions of the learned world, and—what is more amazing—they all agree. Literati of every kind, of all nations and every tongue, orators, philosophers, educators, scientific men, ancient and modern, known and unknown, all are made to support Hamilton's claim, and even the most celebrated mathematicians seem eager to declare that the study of mathematics is unworthy of genius and injures the mind. Whewell was overwhelmed, reduced to silence. His promised rejoinder failed to appear. The Scotchman's victory was complete, his fame enhanced, and his alleged judgment regarding a great human interest of which he was ignorant has reigned over the minds of thousands of men who have been either willing or constrained to depend on borrowed estimates. But even all this may be condoned. Jealousy, vanity, parade of learning, may be pardoned even in a philosopher. Hamilton's deadly sin was none of these, it was sinning against the light. In October, 1877, A. T. Bledsoe, then editor of the *Southern Review*—unfortunately too little

known—published an article in that journal in which he proved beyond a reasonable doubt—I have been at the pains to verify the proof—that Hamilton by studied selections and omissions deliberately and maliciously misrepresented the great authors from whom he quoted—d’Alembert, Blaise Pascal, Descartes and others—distorting their express and unmistakable meaning even to the extent of complete inversion. This same verdict regarding Hamilton’s vandalism, in so far as it relates to the works of Descartes, was independently reached by Professor Pringsheim and in 1904 announced by him in his *Festrede* before the Munich Academy of Sciences. As for Schopenhauer, I regret to say that a similar charge and finding stand against him also. For not only did he endorse without examination and re-utter Hamilton’s tirade in the strongest terms, thus reinforcing it and giving it currency on the continent, but, as Pringsheim has shown, the German philosopher, by careful excision from the writings of Lichtenberg, converts that distinguished physicist’s just strictures on the then flourishing but wayward Combinatorial School of mathematics into a severe condemnation of mathematicians in general and of the science itself, which, nevertheless, in the opening but omitted line of the very passage from which Schopenhauer quotes, is characterized by Lichtenberg as “*eine gar herrliche Wissenschaft.*” Regarding the question of the intrinsic merit of the estimate of mathematics which these two most famous and influential enemies of the science have made so largely current in the world that it fairly fills the atmosphere and people take it in unconsciously as by a kind of cerebral suction, I shall speak in another connection. What I desire to emphasize here is the fact that neither the vast, splendid, superficial learning of the pompous author of “The Philosophy of the Conditioned” nor the pungence and pith, brilliance and intrepidity of the author of “Die

Welt als Wille" can avail to constitute either of them an authority in a subject in which neither was informed and in which both stand convicted falsifiers of the judgments and opinions of other men.

As to Huxley and Holmes, the case is different. Both of them were generous, genial and honest, and to their opinions on any subject we gladly pay respect qualified only as the former's judgment regarding mathematics was qualified by Sylvester himself:

"Verständige Leute kannst du irren sehn
In Sachen nämlich, die sie nicht verstehn."

In relation to Huxley's statement that mathematical study knows nothing of observation, induction, experiment, and causation, it ought to be borne in mind that there are two kinds of observation: outer and inner, objective and subjective, material and immaterial, sensuous and sense-transcending; observation, that is, of physical things by the bodily senses, and observation, by the inner eye, by the subtle touch of the intellect, of the entities that dwell in the domain of logic and constitute the objects of pure thought. For, phrase it as you will, there is a world that is peopled with ideas, ensembles, propositions, relations, and implications, in endless variety and multiplicity, in structure ranging from the very simple to the endlessly intricate and complicate. That world is not the product but the object, not the creature but the quarry of thought, the entities composing it—propositions, for example,—being no more identical with thinking them than wine is identical with the drinking of it. Mind or no mind, that world exists as an extra-personal affair,—Pragmatism to the contrary notwithstanding. It appears to me to be a radical error of pragmatism to blink the fact that the most fundamental of spiritual things, namely, curiosity, never poses as a maker of

truth but is found always and only in the attitude of seeking it. Indeed truth might be defined to be the presupposition or the complement of curiosity—as that without which curiosity would cease to be what it is. The constitution of that extra-personal world, its intimate ontological make-up, is logic in its essential character and substance as an independent and extra-personal form of being, while the study of that constitution is logic pragmatically, in its character, *i.e.*, as an enterprise of mind. Now—and this is the point I wish to stress—just as the astronomer, the physicist, the geologist, or other student of objective science looks abroad in the world of sense, so, not metaphorically speaking but literally, the mind of the mathematician goes forth into the universe of logic in quest of the things that are there; exploring the heights and depths for facts—ideas, classes, relationships, implications, and the rest; observing the minute and elusive with the powerful microscope of his Infinitesimal Analysis; observing the elusive and vast with the limitless telescope of his Calculus of the Infinite; making guesses regarding the order and internal harmony of the data observed and collocated; testing the hypotheses, not merely by the complete induction peculiar to mathematics, but, like his colleague of the outer world, resorting also to experimental tests and incomplete induction; frequently finding it necessary, in view of unforeseen disclosures, to abandon a once hopeful hypothesis or to transform it by retrenchment or by enlargement:—thus, in his own domain, matching, point for point, the processes, methods and experience familiar to the devotee of natural science.

Is it replied that it was not observation of the objects of pure thought but the other kind, namely, sensuous observation, that Huxley had in mind, then I rejoin that, nevertheless, observation by the inner eye of the things of thought *is* observation, not less genuine, not less difficult,

not less rich in its objects and disciplinary value, than is sensuous observation of the things of sense. But this is not all, nor nearly all. Indeed for direct beholding, for immediate discerning, of the things of mathematics there is none other light but one, namely, psychic illumination, but mediate and indirectly they are often revealed or at all events hinted by their sensuous counterparts, by indications within the radiance of day, and it is a great mistake to suppose that the mathetic spirit elects as its agents those who, having eyes, yet see not the things that disclose themselves in solar light. To facilitate eyeless observation of his sense-transcending world, the mathematician invokes the aid of physical diagrams and physical symbols in endless variety and combination; the logos is thus drawn into a kind of diagrammatic and symbolical incarnation, gets itself externalized, made flesh, so to speak; and it is by attentive physical observation of this embodiment, by scrutinizing the physical frame and make-up of his diagrams, equations and formulae, by experimental substitutions in, and transformations of, them, by noting what emerges as essential and what as accidental, the things that vanish and those that do not, the things that vary and the things that abide unchanged, as the transformations proceed and trains of algebraic evolution unfold themselves to view,— it is thus, by the laboratory method, by trial and by watching, that often the mathematician gains his best insight into the constitution of the invisible world thus depicted by visible symbols. Indeed the importance to the mathematician of such sensuous observation cannot be over-rated. It is not merely that the craving to see has led to the construction of the manifold models, ingenious and noble, of Schilling and others, illustrating important parts of Higher Geometry, Analysis Situs, Function Theory and other doctrines, but the annals of the science are illustrious with achievements made possible by facts first noted by

the physical eye. To take a simple example from ancient days, it was by observation of the fact that the squares of certain numbers are each the sum of two other squares, the detection and collection of these numbers by the method of trial, observation of the fact that apparently all and only the numbers of such triplets are measures of the sides of right triangles,—it was thus, by observation and experiment, by the method of incomplete induction, common to the experimental sciences, that the Pythagorean theorem, now familiar throughout the world, was discovered. It was by Leibniz's observation of the definitely lawful manner in which the coefficients of a system of equations enter their solution that the suggestion came of a notion on the basis of which there has grown up in our time an imposing theory, an algebra built up on algebra—the colossal doctrine of Determinants. It was the observation, the detection by the eye of Lagrange and Boole and Eisenstein, of the fact that linear transformation of certain algebraic expressions leaves certain functions of their coefficients absolutely undisturbed in form, unaltered in frame of constitution, that gave rise to the concept, and therewith to the morphological doctrine, of Invariants, a theory filling the heavens like a light-bearing ether, penetrating all the branches of geometry and analysis, revealing everywhere abiding configurations in the midst of change, everywhere disclosing the eternal reign of the law of Form. It was in order to render evident to sensuous observation and to keep constantly before the physical eye the pervasive symmetry of mathematical thought that Hesse in the employment of homogeneous coördinates set the example, since then generally followed, of replacing a variety of different letters by repetitions of a single one distinguished by indices or subscripts,—a practice yet further justified on grounds both of physical and of intellectual economy. It was by sensuous observation that Clerk Maxwell, in the beginning

of his wondrous career, detected a lack of symmetry in the then recognized equations of electro-dynamics and by that observed fact together with a discriminating sense of the scientific significance of esthetic intimations, that he was led to remove the seeming blemish by the addition of a term, antedating experimental justification of his daring deed by twenty years: an example of prescience not surpassed by that of Adams and Leverrier who, while engaged in the study of planetary disturbance, each of them about the same time and independently of the other, felt the then unknown Neptune "trembling on the delicate thread of their analysis" and correctly informed the astronomer where to point his telescope in order to behold the planet. One might go on to cite the theorem of Sturm in Equation Theory, the "Diophantine theorems of Fermat" in the Theory of Numbers, the Jacobian "doctrine of double periodicity" in Function Theory, Legendre's law of reciprocity, Sylvester's reduction of Euler's problem of the Virgins to the form of a question in Simple Partitions, and so on and on, thus continuing indefinitely the story of the great rôle of observation, experiment and incomplete induction, in mathematical discovery. Indeed it is no wonder that even Gauss, "*facile princeps mathematicorum*," even though he dwelt aloft in the privacy of a genius above the needs and ways of other minds, yet pronounced mathematics "a science of the eye."

Indeed the time is at hand when at least the academic mind should discharge its traditional fallacies regarding the nature of mathematics and thus in a measure promote the emancipation of criticism from inherited delusions respecting the kind of activity in which the life of the science consists. Mathematics is no more the art of reckoning and computation than architecture is the art of making bricks or hewing wood, no more than painting is the art of mixing colors on a palette, no more than the science of geol-

ogy is the art of breaking rocks, or the science of anatomy the art of butchering.

Did not Babbage or somebody invent an adding machine? And does it not follow, say Holmes and Schopenhauer, that mathematical thought is a merely mechanical process? Strange how such trash is occasionally found in the critical offering of thoughtful men and thus acquires circulation as golden coin of wisdom. It would not be sillier to argue that, because Stanley Jevons constructed a machine for producing certain forms of logical inference, therefore all thought, even that of a philosopher like Schopenhauer or that of a poet like Holmes, is merely a thing of pulleys and levers and screws, or that the pianola serves to prove that a symphony by Beethoven or a drama by Wagner is reducible to a trick of mechanics.

But far more pernicious, because more deeply imbedded and persistent, is the fallacy that the mathematician's mind is but a syllogistic mill and that his life resolves itself into a weary repetition of A is B , B is C , therefore A is C ; and *Q.E.D.* That fallacy is the *Carthago delenda* of regnant methodology. Reasoning, indeed, in the sense of compounding propositions into formal arguments, is of great importance at every stage and turn, as in the deduction of consequences, in the testing of hypotheses, in the detection of error, in purging out the dross from crude material, in chastening the deliverances of intuition, and especially in the final stages of a growing doctrine, in welding together and concatenating the various parts into a compact and coherent whole. But, indispensable in all such ways as syllogistic undoubtedly is, it is of minor importance and minor difficulty compared with the supreme matters of Invention and Construction. *Begriffbildung*, the resolution of the nebula of consciousness into star-forms of definite ideas; discriminating sensibility to the logical significances, affinities and bearings of these; susceptibility to the delicate

intimations of the subtle or the remote; sensitiveness to dim and fading tremors sent below by breezes striking the higher sails; the ability to grasp together and to hold in steady view at once a multitude of ideas, to transcend the individuals and, compounding their forces, to seize the resultant meaning of them all; the ability to summon not only concepts but doctrines, marshalling them and bringing them to bear upon a single point, like great armies converging to a critical centre on a battle field. These and such as these are the powers that mathematical activity in its higher rôles demands. The power of ratiocination, as already said, is of exceeding great importance but it is neither the base nor the crown of the faculties essential to "Mathematicised Man." When the greatest of American logicians, speaking of the powers that constitute the born geometrician, had named Conception, Imagination, and Generalization, he paused. Thereupon from one in the audience there came the challenge, "What of Reason?" The instant response, not less just than brilliant, was: "Ratiocination—that is but the smooth pavement on which the chariot rolls." When the late Sophus Lie, great comparative anatomist of geometric theories, creator of the doctrines of Contact Transformations, and Infinite Continuous Groups, and revolutionizer of the Theory of Differential Equations, was asked to name the characteristic endowment of the mathematician, his answer was the following quaternion: *Phantasie, Energie, Selbstvertrauen, Selbstkritik*. Not a word, you observe, about ratiocination. *Phantasie*, not merely the fine frenzied fancy that gives to airy nothings a local habitation and a name, but the creative imagination that conceives ordered realms and lawful worlds in which our own universe is as but a point of light in a shining sky; *Energie*, not merely endurance and doggedness, not persistence merely, but mental *vis viva*, the kinetic, plunging, penetrating power of intellect; *Selbstvertrauen* and

Selbstkritik, self-confidence aware of its ground, deepened by achievement and reinforced until in men like Richard Dedekind, Bernhard Bolzano and especially Georg Cantor it attains to a spiritual boldness that even dares leap from the island shore of the Finite over into the all-surrounding boundless ocean of Infinitude itself, and thence brings back the gladdening news that the shoreless vast of Transfinite Being differs in its logical structure from that of our island home only in owning the reign of more *generic* law.

Indeed it is not surprising, in view of the polydynamic constitution of the genuinely mathematical mind, that many of the major heroes of the science, men like Desargues and Pascal, Descartes and Leibniz, Newton, Gauss and Bolzano, Helmholtz and Clifford, Riemann and Salmon and Plücker and Poincaré, have attained to high distinction in other fields not only of science but of philosophy and letters too. And when we reflect that the very greatest mathematical achievements have been due, not alone to the peering, microscopic, histologic vision of men like Weierstrass, illuminating the hidden recesses, the minute and intimate structure of logical reality, but to the larger vision also of men like Klein who survey the kingdoms of geometry and analysis for the endless variety of things that flourish there, as the eye of Darwin ranged over the flora and fauna of the world, or as a commercial monarch contemplates its industry, or as a statesman beholds an empire; when we reflect not only that the Calculus of Probability is a creation of mathematics but that the master mathematician is constantly required to exercise judgment—judgment, that is, in matters not admitting of certainty—balancing probabilities not yet reduced nor even reducible perhaps to calculation; when we reflect that he is called upon to exercise a function analogous to that of the comparative anatomist like Cuvier, comparing theories

and doctrines of every degree of similarity and dissimilarity of structure; when, finally, we reflect that he seldom deals with a single idea at a time, but is for the most part engaged in wielding organized hosts of them, as a general wields at once the divisions of an army or as a great civil administrator directs from his central office diverse and scattered but related groups of interests and operations; then, I say, the current opinion that devotion to mathematics unfits the devotee for practical affairs should be known for false on *a priori* grounds. And one should be thus prepared to find that as a fact Gaspard Monge, creator of descriptive geometry, author of the classic “Applications de l’analyse à la géométrie”; Lazare Carnot, author of the celebrated works, “Géométrie de position,” and “Réflexions sur la Métaphysique du Calcul infinitesimal”; Fourier, immortal creator of the “Théorie analytique de la chaleur”; Arago, rightful inheritor of Monge’s chair of geometry; and Poncelet, creator of pure projective geometry; one should not be surprised, I say, to find that these and other mathematicians in a land sagacious enough to invoke their aid, rendered, alike in peace and in war, eminent public service.

To speak at length, if that were necessary, of Huxley’s deliverance that the study of mathematics “knows nothing of causation,” the “law of my song and the hastening hour forbid.” Suffice it to say in passing that when the mathematician seeks the consequences of given suppositions, saying ‘when these precede, those will follow,’ and when, having plied a circle, a sphere or other form chosen from among infinitudes of configurations, with some transformation among infinite hosts at his disposal, he speaks of its ‘effect,’ then, I submit, he is employing the language of causation with as nice propriety as it admits of in a world where, as everyone knows, except such as still enjoy the blessings of a juvenile philosophy, the best we can say is

that the ceaseless shuttles fly back and forth, and streams of events without original source flow on without ultimate termination. Indeed it is a certain and signal lesson of science in all its forms everywhere that the language of cause and effect, except in the sense of facts being lawfully implied in other facts, has no indispensable use.

I have not spoken of "Applied Mathematics," and that for the best of reasons: there is, strictly speaking, no such thing. The term indeed exists, and, in a conservative practical world that cares but little for "The nice sharp quillets of the law," it will doubtless persist as a convenient designation for something that never existed and never can. It is of the very essence of the practician type of mind not to know aught as it is in itself nor aught as self-justified but to mistake the secondary and accidental for the primary and essential, to blink and elude the presence of *immediate* worth, and being thus blind to instant and immanent ends, to revel in means and uses and applications, requiring all things to excuse their being by extraneous and emanant effects,—vindicating the stately elm by its promise of lumber, or the lily by its message of purity, or the flood of Niagara by its available energy, or even knowledge itself by the worldly advantage and the power which it gives. I am told that even the deep and exquisite terminology of art has been to some extent invaded by such barbarous and shallow phrases as 'applied music,' 'applied architecture,' 'applied sculpture,' 'applied painting,' as if Beauty, virgin mother of art, could, without dissolution of her essential character, consciously become the willing drudge and paramour of Use. And I suppose we are fated yet to hear of applied glory, applied holiness, applied poetry—*i.e.*, poetry that is consciously pedagogic or that aims at a moral and thereby sinks or rises to the level of a sermon—of applied joy, applied ontology, yea, of applied inapplicability itself.

It is in implications and not in applications that mathematics has its lair. Applied mathematics is mathematics simply or is not mathematics at all. To think aright is no characteristic striving of a class of men; it is a common aspiration; and Mechanics, Mathematical Physics, Mathematical Astronomy, and the other chief *Anwendungsgebiete* of mathematics, as Geodesy, Geophysics, and Engineering in its various branches, are all of them but so many witnesses to the truth of Riemann's saying that "Natural science is the attempt to comprehend nature by means of exact concepts." A gas molecule regarded as a minute sphere or other geometric form, however complicate; stars and planets conceived as ellipsoids or as points, and their orbits as loci; time and space, mass and motion and impenetrability; velocity, acceleration and energy; the concepts of norm and average;—what are these but mathematical notions? And the wondrous garment woven of them in the loom of logic—what is that but mathematics? Indeed every branch of so-called applied mathematics is a mixed doctrine, being thoroughly analyzable into two disparate parts: one of these consists of determinate concepts formally combined in accordance with the canons of logic, *i.e.*, it is mathematics and not natural science viewed as matter of observation and experiment; the other *is* such matter and is natural science in that conception of it and not mathematics. No fibre of either component is a filament of the other. It is a fundamental error to regard the term Mathematicisation of thought as the importation of a tool into a foreign workshop. It does not signify the transition of mathematics conceived as a thing accomplished over into some outlying domain like physics, for example. Its significance is different radically, far deeper and far wider. It means the growth of mathematics itself, its extension and development from within; it signifies the continuous revelation, the endlessly progressive coming into view, of

the static universe of logic; or, to put it dynamically, it means the evolution of intellect, the upward striving and aspiration of thought everywhere, to the level of cogency, precision and exactitude. This self-propagation of the rational logos, the springing up of mathetic rigor even in void and formless places, in the very retreats of chaos, is to my mind the most impressive and significant phenomenon in the history of science, and never so strikingly manifest as in the last half hundred years. Seventy-two years ago, even Comte, the stout advocate of mathematics as constituting "the veritable point of departure for all rational scientific education, general or special," expressed the opinion that we should never "be in position by any means whatever to study the chemical composition of the stars." In less than twenty-five years thereafter that negative prophecy was falsified by the chemical genius of Bunsen fortified by the mathematics of Kirchoff. Not only has mathematics grown, in the domain of Physics, into the vast proportions of Rational Dynamics, but the derivative and integral of the Calculus, and Differential Equations, are more and more finding subsistence in Chemistry also, and by the work of Nernst and others even the foundations of the latter science are being laid in mathematico-physical considerations. Merely to sketch most briefly the mathematical literature that has grown up in the field of Political Economy requires twenty-five pages of the above mentioned *Encyklopädie* of mathematics. Similar sketches for Statistics and Life Insurance require no less than thirty and sixty-five pages respectively. Even in the baffling and elusive matter of Psychology, the work of Herbart, Fechner, Weber, Wundt and others confirms the hope that the soil of that great field will some day support a vigorous growth of mathematics. It seems indeed as if the entire surface of the world of human consciousness were predestined to be covered over, in varying degrees of luxuriance, by the flora of mathetic science.

But while mathematics may spring up and flourish in any and all experimental and observational fields, it is by no means to be expected that 'experiment and observation' will ever thus be superseded. Such domains are rather destined to be occupied at the same time by two tenants, mathematical science and science that is not mathematical. But while the former will serve as an ideal standard for the latter, mathematics has neither the power nor the disposition to dispossess experiment and observation of any holdings that are theirs by the rights of conquest and use. Between mathematics on the one hand and non-mathematical science on the other, there can never occur collision or quarrel, for the reason that the two interests are ultimately discriminated by the kind of curiosity whence they spring. The mathematician is curious about definite naked relationships, about logically possible modes of order, about varieties of implication, about completely determined or determinable functional relationships, considered solely in and of themselves, considered, that is, without the slightest concern about any question whether or no they have any external or sensuous validity or other sort of validity than that of being logically thinkable. It is the aggregate of things thinkable logically that constitutes the mathematician's universe, and it is inconceivably richer in mathetic content than can be any outer world of sense such as the physical universe according to which we chance to have our physical being.

This mere speck of a physical universe in which the chemist, the physicist, the astronomer, the biologist, the sociologist, and the rest of nature students, find their great fields and their deep and teeming interests, may be a realm of invariant uniformities, or laws; it may be a mechanically organic aggregate, connected into an ordered whole by a tissue of completely definable functional relationships; and it may not. It may be that the universe eternally has been and is a genuine cosmos; it may be that the external

sea of things immersing us, although it is ever changing infinitely, changes only lawfully, in accordance with a system of immutable rules of order that constitute an invariant at once undervived and indestructible and securing everlasting harmony through and through; and it may not be such. The student of nature assumes, he rightly assumes, that it is; and, moved and sustained by characteristic appropriate curiosity, he endeavors to find in the outer world what are the elements and what the relationships assumed by him to be valid there. The mathematician as such does not make that assumption and does not seek for elements and relationships in the outer world.

Is the assumption correct? Undoubtedly it is admissible, and as a working hypothesis it is undoubtedly exceedingly useful or even indispensable to the student of external nature; but is it true? The mathematician as man does not know although he cares. Man as mathematician neither knows nor cares. The mathematician does know, however, that, if the assumption be correct, every relationship that is valid in nature is, *in abstractu*, an element in his domain, a subject for his study. He knows, too, at least he strongly suspects, that, if the assumption be not correct, his domain remains the same absolutely, and the title of mathematics to human regard "would remain unimpeached and unimpaired" were the universe without a plan or, having a plan, if it "were unrolled like a map at our feet, and the mind of man qualified to take in the whole scheme of creation at a glance."

The two realms, of mathematics, of natural science, like the two curiosities and the two attitudes, the mathematician's and the nature student's, are fundamentally distinct and disparate. To think logically the logically thinkable—that is the mathematician's aim. To assume that nature is thus thinkable, an embodied rational logos, and to discover the thought supposed incarnate there—these

are at once the principle and the hope of the student of nature.

Suppose the latter student is right and that the outer universe really is an embodied logos of reason, does it follow that all the logically thinkable is incorporated in it? It seems not. Indeed there appears to be many a rational logos. A cosmos, a harmoniously ordered universe, one that through and through is self-compatible, can hardly be the whole of reason materialized and objectified. At all events the mathematician has delight in the conceptual construction and in the contemplation of divers systems that are inconsistent with one another though each is thoroughly self-coherent. He constructs in thought a summitless hierarchy of hyperspaces, an endless series of ordered worlds, worlds that are possible and logically actual. And he is content not to know if any of them be otherwise actual or actualized. There is, for example, a Euclidian geometry and there are infinitely many kinds of non-Euclidian. These doctrines, regarded as *true* descriptions of some one actual space, are incompatible. In our universe, to be specific, if it be as Plato thought and natural science takes for granted, a geometrized or geometrizable affair, then one of these geometries may be, none of them may be, not all of them can be, objectively valid. But in the infinitely vaster world of pure thought, in the world of mathesis, all of them are valid; there they co-exist, there they interlace and blend among themselves and others as differing strains of a hypercosmic harmony.

It is from some such elevation, not the misty lowland of the sensuously and materially Actual, but from a mount of speculation lawfully rising into the azure of the logically Possible, that one may glimpse the dawn heralded by the avowal of Leibniz: "*Ma métaphysique est toute mathématique.*" Time fails me to deal fittingly with the great theme herewith suggested, but I cannot quite forbear to

express briefly my conviction that, apart from its service to kindred interests of thought as a standard of clarity, rigor and certitude, mathematics is and will be found to be an inexhaustible quarry of material—of ontologic types, of ideas and problems, of distinctions, discriminants and hints, evidences, analogies and intimations—all for the exploitation and use of Philosophy, Psychology, and Theology. The allusion is not to such celebrated alliances of philosophy and mathesis as flourished in the school of Pythagoras and in the gigantic personalities of Plato, Descartes, Spinoza, and Leibniz, nor to the more technical mathematico-philosophical researches and speculations of our own time by such as C. S. Peirce, Russell, Whitehead, Peano, G. Cantor, Couturat and Poincaré, glorious as were those alliances and important as these researches are. The reference is rather to the unappreciated fact that the measureless accumulated wealth of the realm of exact thought is at once a marvelous mine of subject matter and a rich and ready arsenal for those great human concerns of reflective and militant thought that is none the less important because it is not exact.

For the vindication of that claim, a hint or two must here suffice. The modern mathematical concepts of number, time, space, order, infinitude, finitude, group, manifold, functionality, and innumerable hosts of others, the varied processes of mathematics, and the principles and modes of its growth and evolution, all of these or nearly all still challenge and still await those kinds of analysis that are proper to the philosopher and the psychologist. The psychology of Euclidian, non-Euclidian, and hyper spaces, the question of the intuitability of the latter, the secret of their having become not only indispensable in various branches of mathematics but instrumentally useful in other fields also, as in the kinetic theory of gases; the question, for example, why it is that while *thought* maintains a straightforward

course through four-dimensional space, *imagination* travels through it on a zig-zag path, of two logically identical configurations, being partially or completely blind to the one, yet perfectly beholding the other; the evaluation and adjustment of the contradictory claims of Poincaré and his school on the one hand and of Mach and his disciples on the other, the former contending that Modern Analysis is a "free creation of the human spirit" guided indeed but not constrained by experience of the external world, being merely kept by this from aimless wandering in wayward paths; while the latter maintain that mathematical concepts, however tenuous or remote or recondite, have been literally evolved continuously in accordance with the needs of the animal organism and with environmental conditions out of the veriest elements (feelings) of physical life, and accordingly that the purest offspring of mathematical thought may trace a legitimate lineage back and down to the lowliest rudiments of physical and physiological experience:—these problems and such as these are, I take it, problems for the student of mind as mind and for the student of psycho-physics.

Regarding the relations of mathesis to the former "queen of all the sciences," I have on this occasion but little to say. I do not believe that the declined estate of Theology is destined to be permanent. The present is but an interregnum in her reign and her fallen days will have an end. She has been deposed mainly because she has not seen fit to avail herself promptly and fully of the dispensations of advancing knowledge. The aims, however, of the ancient mistress are as high as ever, and when she shall have made good her present lack of modern education and learned to extend a generous and eager hospitality to modern light, she will reascend, and will occupy with dignity as of yore an exalted place in the ascending scale of human interests and the esteem of enlightened men. And

mathematics, by the character of her inmost being, is especially qualified, I believe, to assist in the restoration. It was but little more than a generation ago that the mathematician, philosopher and theologian, Bernhard Bolzano, dispelled the clouds that throughout all the foregone centuries had enveloped the notion of Infinitude in darkness, completely sheared the great term of its vagueness without shearing it of its strength, and thus rendered it forever available for the purposes of logical discourse. Whereas, too, in former times the Infinite betrayed its presence not indeed to the faculties of Logic but only to the spiritual Imagination and Sensibility, mathematics has shown, even during the life of the elder men here present,—and the achievement marks an epoch in the history of man,—that the structure of Transfinite Being is open to exploration by the organon of Thought. Again, it is in the mathematical doctrine of Invariance, the realm wherein are sought and found configurations and types of being that, amid the swirl and stress of countless hosts of transformations, remain immutable, and the spirit dwells in contemplation of the serene and eternal reign of the subtle law of Form, it is there that Theology may find, if she will, the clearest conceptions, the noblest symbols, the most inspiring intimations, the most illuminating illustrations, and the surest guarantees of the object of her teaching and her quest, an Eternal Being, unchanging in the midst of the universal flux.

It is not, however, by any considerations or estimates of utility in any form however high it be or essential to the worldly weal of man; it is not by evaluating mastery of the processes of measurement and computation, though these are continuously vital everywhere to the conduct of practical life; nor is it by strengthening the arms of natural science and speeding her conquests in a thousand ways and a hundred fields; nor yet by extending the empire of the

human intellect over the realms of number and space and establishing the dominion of thought throughout the universe of logic; it is not even by affording argument and fact and light to theology and so contributing to the advancement of her supreme concerns;—it is not by any of these considerations nor by all of them that Mathematics, were she called upon to do so, would rightly seek to vindicate her highest claims to human regard. It requires indeed but little penetration to see that no science, no art, no doctrine, no human activity whatever, however humble or high, can ultimately succeed in justifying itself in terms of measurable fruits and emanant effects, for these remain always to be themselves appraised, and the process of such attempted vindication is plainly fated to issue only in regression without an end. Such Baconian apologetic, when offered as final, quite mistakes the finest mood of the scientific spirit and is beneath the level of academic faith. Science does not seek emancipation in order to become a drudge, she consents to serve indeed but her service aims at freedom as an end.

Man has been so long a slave of circumstance and need, he has been so long constrained to seek license for his summit faculties, in lower courts without appeal, that a sudden transitory moment of release sets him trembling with distrust and fear, an occasional imperfect vision of the instant dignity of his spiritual enterprises is at once obscured by doubt, and he straightway descends into the market places of the world to excuse or to justify his illumination, pleading some mere utility against the ignoring or the condemnation of an insight or an inspiration whose worth is nevertheless immediate and no more needs and no more admits of utilitarian justification than the breaking of morning light on mountain peaks or the bounding of lambs in a meadow.

The solemn cant of Science in our day and her sombre

visage are but the lingering tone and shade of the prison-house, and they will pass away. Science is destined to appear as the child and the parent of freedom blessing the earth without design. Not in the ground of need, not in bent and painful toil, but in the deep-centred play-instinct of the world, in the joyous mood of the eternal Being, which is always young, Science has her origin and root; and her spirit, which is the spirit of genius in moments of elevation, is but a sublimated form of play, the austere and lofty analogue of the kitten playing with the entangled skein or of the eaglet sporting with the mountain winds.

PHYSICS

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
AS THE OPENING LECTURE IN THE NATURAL SCIENCE GROUP
OCTOBER 23, 1907**



PHYSICS

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New York

THE COLUMBIA UNIVERSITY PRESS

1907

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Set up, and published December, 1907.

PHYSICS

IN the upbuilding of all the great and diverse departments of thought, characteristic methods have arisen which the human reason has found best suited to the pursuit of the many phases of truth which it seeks. In the perfection of methods and resourcefulness in applying them, no age has been more fertile than our own. Yet one ever present danger to the orderly and symmetrical development of modern thought, is that those working in different fields for its advancement may lose touch with one another, and the interchange of methods and results so essential to balanced growth, be neglected.

If in such a course of lectures as this, each lecturer coming from a neighboring or distant field succeeds in showing the nature of the evidence he has been taught to consider, his methods of weighing it and some of his results, the university will be the gainer in increased knowledge, in broadened sympathies and in a deeper realization of the wholeness of truth.

It is doubtful if our understanding of the unity of external nature can ever be illuminated by the lamp of any one of the natural sciences. The division of nature into separate departments of study has been an intellectual necessity caused by the greatness of the task.

The easiest cleavage would separate the animate from the inanimate, the biological from the physical sciences. This cleft, the first to form, will be the last to close; for to

define the precise relations of life to matter is now one of the most intricate and difficult problems in the whole range of human endeavor. Who will fundamentally answer the question, how does a seed become a tree?

The phenomena of inanimate matter are involved and complicated in the extreme, but those of living matter are even harder to understand. The outward or objective manifestations of life, are of a material or physical character, and the purpose of the biologist is to apply to them the principles of physics and chemistry as far as these will carry him, and in many directions they have already carried him far. When however we consider the subjective phenomena of life, or consciousness, the question seems to me a metaphysical one and we are without assurance that physics and chemistry can lead us beyond the boundaries of it. Indeed just where physics and chemistry leave off, I feel a real and deeper problem begins. If so, the question lies at present beyond the reach of natural science which biologist and physicist alike interpret as the science of matter and energy.

In what follows I shall try to review very briefly the principal ideas upon which modern physics rests and shall say something about where we think we have arrived in our search for knowledge. I need scarcely remind you that in the natural sciences as in more practical affairs, *how* we have arrived is as important as *where* we have arrived. I shall therefore spend some time in presenting detached fragments of the experimental evidence and inferences upon which certain conclusions are based, hoping in this way to illustrate some of the constructive methods of reasoning employed in research.

The ideas which underlie all our thinking are space, time and inertia or mass. With space and time as a background, the physicist must pursue inertia and everything related to it, along every conceivable path. In this pursuit

he comes upon four ultimate though related conceptions: Matter, Ether, Electricity and Energy.

The historical development of these conceptions cannot even be sketched in such a lecture as this, but it should be remembered an important part of our present knowledge of matter, and nearly all that we know of the ether and electricity, has been gained not immediately but by inference. In so many cases we see or know directly only the first and last link of a chain of events and must search by indirect means for the mechanism lying between.

At bottom, I suppose, the ether, electricity, force, energy, molecule, atom, electron, are but the symbols of our groping thoughts, created by an inborn necessity of the human mind which strives to make all things reasonable. In thus reasoning from things seen and tangible, to things unseen and intangible, the resources of mathematical analysis are applied to the mental images of the investigator, images often suggested to him by his knowledge of the behavior of material bodies. This process leads first to a working hypothesis, which is then tested in all its conceivable consequences, and any phenomena not already known which it requires for its fulfilment, are sought in the laboratory. By this slow advance a working hypothesis which has satisfied all the demands put upon it gradually becomes a theory which steadily gains in authority as more and more new lines of evidence converge upon it and confirm it.

If we now consider more closely the nature of the conceptions, matter, ether, electricity and energy, we shall later find that matter, ether and electricity possess some attributes in common, and if we take careful heed to what we shall understand by the word, we may call them substances. Energy appears as the measure of their possible interactions.

Taking energy first: All the numberless changes we

see taking place in the universe are, we think, manifestations of the interactions among matter, ether and electricity. With every changing aspect of nature, energy is passing from body to body and undergoing incessant transformations, but its amount is always measurable by the work it may accomplish when harnessed.

Our knowledge of the uncreatable and indestructible character of energy has given us a universal test which we may freely apply to all phenomena to prove our knowledge of them. For when the required energy relations are not satisfied by our explanations, it means we have not got to the bottom of the case, but must strike deeper in to realize the whole of the concealed mechanism.

Charmed by the simplicity and sweep of the law of the conservation of energy, a small school of physicists, who have mostly entered in by the door of physical chemistry, have frankly set energy before inertia and have endeavored to deduce matter and all else from it. This can of course be done, for physics has become a body of thought so closely knit together that all things in it are somehow related. Seen broadly however the new method has few obvious advantages over the historic procedure and not a few evident defects.

Matter has two indisputable hallmarks, two properties in the possession of which all the infinitely varied forms of matter unite, inertia and weight. By inertia we mean that active resistance shown by every piece of matter to any effort to change its motion; while the mutual attraction between all material bodies, according to which all matter strives to collect itself into one huge compact lump, we call gravitation. The gravitational pull of the earth upon a portion of matter is its weight. If we find anything in the world however strange which possesses both inertia and weight, we may call it matter without further examination.

The ether which surrounds and encloses all our universe we came first to know as the bearer of waves of light and heat. Ever since that time we have known it to possess inertia; for no medium devoid of inertia can carry forward a wave motion.

Thus the ether has one of the hallmarks of matter. Has it also weight? This we cannot hope to know until we find some way as yet undiscovered to alter the natural distribution of ether between two portions of space. Here it should be remembered that the weight of gases was first proved after the invention of the air pump and barometer. But alas, how shall we go about building an ether pump when all material walls seem more porous to the ether than the coarsest sieve is to air? And worse, the ether appears to be incompressible. The question of weight is thus at present in abeyance and we leave it.

Of the properties of electricity alone, it is still difficult to speak. The subject is easiest approached from the relations of electricity to ether on the one hand and the relations of electricity to matter on the other. It is in this last and more complicated phase of our subject, that the most brilliant advances have recently been made.

To state the case between electricity and ether, we must begin with Faraday and some of the mental images he formed of the connection between them, which have proved at once the most simple and useful aids to thought to be found in the whole history of physics. Faraday realized as well perhaps as we do to-day that electricity could no more be made outright, than could matter. The utmost which could be done was to separate positive and negative electricity. If therefore, any one exhibited a positive charge, there was somewhere in the universe an equal negative charge, to which it was drawn by invisible means across the intervening space.

Faraday maintained the forces of attraction were due to

some kind of strain in the ether lying between. To picture the more vividly to himself and to others, the character of the stresses in this medium transmitting the force which one charge exerts upon another, he supposed contractile filaments called lines of force to traverse the ether between the charges. To make the case more definite he gave direction to these lines assuming that they originated on the positive charge and terminated on an equal negative charge nearby, or far away, according to circumstances.

The motions of electric charges when free to move, and the distribution of stresses in the ether roundabout, show that all happens as if each line of force were pulling like a stretched elastic thread to shorten itself and draw the charges together, and at the same time unlike any elastic thread we know, it was repelling or pushing sidewise at the other force lines near it.

If a charge of positive electricity be given to a metal sphere, and the negative charge from which it has been separated be dissipated to remote bodies or be carried so far away that its position is no longer of any immediate importance, lines of force will start from the spherical surface of the conductor in all outward directions, and will be precisely radial. As many lines will leave from any one half of the sphere as from another. This equal radial arrangement of the lines of force is produced by the sidewise shoving of each line of force upon its neighbors until the stresses in the ether at the bounding surface of the metal are equal on all sides.

If now the metal sphere with its charge be put in steady motion, it will carry its lines of force along with it, and if the motion be not too swift, all the lines of force will continue radial. But with this motion of the lines of electric force through the ether, a wholly new and additional ethereal force appears—a magnetic force which did not exist when the charge was at rest. This magnetic force is al-

ways at right angles both to the lines of electric force and to the direction of their motion, thus encircling the moving charge. The planes of these circles are perpendicular to the straight path along which the charge is travelling.

As long as the motion and charge remain uniform there will be no change whatever in this magnetic force except that it keeps abreast of the sphere as do the moving lines of electric force on which it depends. As soon as the motion ceases the magnetic force disappears and soon all is as it was before the motion began. But while the sphere is starting or stopping, before it has reached its steady motion or while it is coming to rest, the electric and magnetic forces are undergoing readjustment and this disturbance spreads outward through the ether with a speed precisely equal to the speed of light. Nor is this a chance agreement for we now know that light consists of nothing more than very rapidly and periodically changing electro-magnetic forces travelling out through the ether from a particular source of electric disturbance, called a luminous body. The ethereal phenomena we have noted around a moving charge faithfully repeat themselves about a wire carrying an electric current and it was here that Faraday found them.

To the mental images of Faraday—these lines of force which helped him to grapple with the unseen, to form working hypotheses, to experiment: to these Maxwell applied the powerful resources of mathematical analysis and reared the splendid structure of the electro-magnetic theory. Now that the work is done we may let fall the scaffolding which Faraday's vivid imagination supplied but we could not earlier have done without it. Here we have the whole chain, mental image, hypothesis, experiment, theory.

As we now take up what we believe to be the relations of electricity to matter, we come in places upon slippery

ground and the bases of our faith rest on recent foundations.

At the outset we encounter one striking difference between electricity and matter. Every free charge exerts a force upon every other charge in the universe, just as every particle of matter exerts a force on every other particle of matter however distant. But with matter the particles are invariably urged toward each other while electric charges may be either drawn together or forced apart depending on the kinds of charges. We have both positive and negative electricity but only one kind of matter.

Just how these two kinds of electricity are different we know little beyond the invariable law that positive attracts negative and repels positive. In some ways positive and negative electricity resemble right and left handed things. If the same number of right and left handed turns be given to a screw, one hand will precisely undo the work of the other. If the right and left hands be brought together they fit part for part, but two right gloves are a poor pair. On the contrary there is no right and left to gravitation. Two pieces of matter always fit in the gravitational sense.

The bald statements of the laws of gravitation and electric force bear a strong resemblance to each other. The laws tell us how the forces *vary*, but reveal no hint of the machinery by which they *act*.

Gravitation was the first force man encountered and it is still the one he knows least about for we have got no further than where Newton left it two and a half centuries ago. We have some inkling of the possible machinery by which one electric charge acts upon another at a distance and we feel nearly as sure that the push or pull is carried by the ether as that the pull of a horse on a cart is through the traces which bind him to it. With gravitation the case is very different for we have n't as yet the slightest valid conception of *how* the pull of one mass upon another is

conducted across the intervening space, nor *what* conducts it. We can get no further until the speed with which gravitational disturbances travel has been measured, and no one at present seems to know how to go about making such an experiment.

One further difference between gravitation and electric force. The force of attraction or repulsion between two charges of electricity is diminished by replacing the free ether between them with any material medium, but the force of gravitation between two bodies remains constant as long as the distance remains constant, and intervening masses are powerless to shield or to alter it. Hence we cannot yet attribute the gravitation of matter to any electricity which may be contained in it, nor prove the ether to be the medium through which the force acts.

Gravitation is still unconnected, unattached to anything else in nature; as independent as Mr. Kipling's "cat that walked by himself, and all places were alike to him." It is still the stumbling block to the physicist which it has been these many years. How can he explain a universe when he is unable to give a reasonable account of the cement which holds it together?

Of the intimate association of electricity with matter we have learned much from careful study of the processes of electric conduction in solutions and gases.

When a simple chemical compound, (and it should here be borne in mind that the molecule of a compound is built up of atoms of at least two different kinds)—when a simple chemical compound, hydrochloric acid for example, is dissolved in water and an electric current is passed through the solution, the products hydrogen and chlorine of the decomposed acid appear in definite proportions at the points where the current enters and leaves the liquid—the chlorine where the current enters, the hydrogen where it leaves. We know this current to consist of processions

of single charged atoms, a disorderly march perhaps, with a crowd of bystanders obstructing the way, but the movement is always forward, each constituent of the broken molecule carrying a definite electric charge. These processions are always double. The atomic carriers of the positive charge moving in one direction, those carrying the negative charge in the other. The same quantity of positive electricity is carried by one procession, as negative electricity by the other. We have not only measured the charge carried by a single atom but the average speed with which the atoms traverse the solution. It has been found further that atoms of the different chemical elements having the same mating value, technically called valence, always carry the same unvarying charge whether the atoms themselves be light or heavy. These charged atoms, in some cases atom groups, are spoken of as *ions*.

Such electrolytic experiments as these have led to two surprising results. First: no electric charge smaller than that carried by an atom of the hydrogen valence has yet been found. Second: all other small charges are exact multiples of this value.

We have long been familiar with the idea of atoms of matter but here for the first time we come across something which looks very like an atom, or natural unit, of electricity. The justification for calling it an atom of electricity is like the argument for the atom of matter. Moreover we know some eighty different kinds of material atoms but only two kinds of electric atoms, a positive and a negative. Thus the electric atom of the two has the greater claim to simplicity. When we speak of an electric atom disregarding for the time the matter associated with it, we call it, not an *ion* but an *electron*. Evidence will later be given suggesting ways by which we may wrench a negative electron wholly free from matter, and experiment with it in its detached and pure state.

We are now in a position to consider the rôle electric forces play in holding atoms together within a compound molecule, for, from the foregoing, it appears when a molecule is broken in two, the fragments are always found equally and oppositely charged, and they doubtless held these charges within the molecule. But the distance separating the two parts was then so small that all the lines of force from the positive charge ended at once on the equal negative charge, and no force lines strayed beyond the molecular boundary. Hence no evidence of an electrical charge could be found in the ether outside the molecule. It seems probable therefore that the electric force between the atoms of matter in the molecule supplies the chemist with the cement he has long called *chemical affinity*.

The ratio of the electric charge to the mass of the particle on which it rides (in our processions) has come to be one of the most important quantities in physics. As we know both the quantity of matter and quantity of electricity transferred by a given electric current, we can express this ratio for each chemical element. Hydrogen gives the largest ratio found in solutions.

Systematic study of the conduction of electricity in gases is of more recent origin but the knowledge gained from it not only confirms the ideas formed to explain conduction in solutions, but has very widely extended and simplified them. The chief difference between electric conduction in solutions and conduction in gases arises from the large number of broken molecules or ions always present in solutions. These require only the presence of an electromotive force to start them marching, but a gas, in its natural or non-conducting state, contains very few ions, not enough to support even a very small current, and for this reason gases are insulators.

In gases however there are many ways of making ions, X-rays, radium rays, rays of ultra violet light on metals,

combustion in flames, white hot bodies of every sort will do it. But there is one method which depends on the violent collisions of ions with molecules which is so objective in its form I cannot forbear attempting to describe it. It is also the method which leads us to cathode rays and much more.

Imagine then a glass tube into each end of which a conducting rod carrying a small metal disc is sealed. These rods may at will be connected to the terminals of a battery. If while the tube is filled with a gas, in its non-conducting state, the battery be applied, the very few ions always present are set in motion but the too frequent collisions in the swarm of neutral molecules which obstruct the way prevent the moving ions from attaining more than moderate speeds.

By connecting the tube to an air pump as many as we like of the interfering molecules may be removed. As more and more gas is drawn out of the tube, the moving ions encounter fewer and fewer collisions and in consequence attain higher and higher speeds, as small shot might fall through a gradually dispersing swarm of bees poised in midair. The longer the pumping is kept up the greater the maximum speed of the ions becomes and the more violent are the collisions which do occur. When nearly all of the gas has been drawn out of the tube, a stage is reached where the encounters between flying ion and indifferent molecule become so violent that molecules are shattered and new ions produced, which in their turn work more destruction.

When this stage is reached, the gas is a good conductor, but if the pumping be carried too far, a second stage appears in which the encounters are too few to make enough new ions to support the current, and the gas finally ceases to conduct systematically. It is near the end of the conducting stage that the much discussed cathode rays appear. They depart from the cathode or metal disc in the end of the tube connected to the negative side of the battery.

The extraordinary resourcefulness, shown by the leading workers in this field of recent enquiry, in untangling the complex snarl of phenomena presented, marks a very great achievement. So inspiring from the human side as well as the physical has been this unequal contest of man with nature, of mind struggling against disorder, and so bravely done, that I ask your indulgence while I try for a few minutes, fragmentarily, to describe one or two fundamental experiments.

Cathode rays are invisible but many substances—fortunately glass is of the number—shine with a bright phosphorescent light when placed in the path of the rays. By this means it was early discovered that cathode rays travel in straight lines which always leave the cathode making right angles with the metal surface from which they depart. It is possible therefore to make the cathode concave or saucer shaped and thus bring the rays to a focus at some point in the tube. If cathode rays are thus focussed upon the blades of a very delicate paddle wheel which rotates easily upon an axis, the wheel is set revolving as if struck by a stream of moving matter.

The rays are found to possess an unusual power of penetrating matter impervious to light. They will even traverse a considerable thickness of aluminum. A comparison of the absorbing powers of different materials for cathode rays shows absorption to be roughly proportional to the density of the substance.

There is a field of magnetic force about a beam of these rays and this added to the transfer of electricity along the path gives to the cathode stream the distinguishing marks of an electric current in a wire or a procession of electrically charged bodies. If a magnet be brought near the tube the cathode stream is deflected from its direct course. This deflection by the magnet shows three things: first, cathode rays are not of the nature of light rays, the path of which a magnet is powerless to change. Second, the curved

path which the stream follows again shows the stream to possess inertia. Third, the side to which the rays are deflected indicates a stream of negative electricity.

Strongly electrified bodies brought near the tube also deflect the rays. It is possible to determine the speed and the ratio of charge to the mass of the cathode particle, by measurements of the curvature of the path due to the combined magnetic and electrostatic deflections. Speeds as high as one tenth the velocity of light or 100,000 times the speed of a modern rifle bullet have thus been observed. The ratio of charge to mass comes out nearly a thousand times that found for the hydrogen atom by electrolysis. If the charge on the cathode particle is no larger than that on the hydrogen atom, which was called an atom of electricity, then the inertia or mass of these particles is only one one-thousandth part of the mass of hydrogen atoms.

The nature of cathode rays was thus determined but at this stage it was all important to catch a known number of these missiles and measure the electric charge each carried. As the estimated size of these minute bodies is less than one ten-million-millionths of an inch, direct counting would be both slow and difficult, yet by one of the most ingenious experiments ever performed, Professor J. J. Thomson did it, indirectly.

To bring the essential features of this remarkable experiment before you, I must begin some way off by reminding you of several things you already know. For instance, the quantity of water vapor which a given volume of air at ordinary pressures can hold without depositing it as a mist or rain, increases with the temperature. If air inclosed in a vessel is allowed to expand suddenly its temperature falls. If the air were initially saturated with water vapor, after the expansion some of the vapor will go into mist or rain provided any nuclei are present upon which the excess vapor can condense. In the ordinary fog

or shower the dust particles always present in the open air act as nuclei for the formation of drops. Small free charges of electricity or ions serve the same purpose and the negative ions are more effective condensers than the positive, hence they come down first.

In a complicated vessel which need not be described, Professor Thomson admitted dust free air saturated with water vapor. This mixture was allowed to expand several times to make sure of freeing it from accidental dust or ions which might be present. The former pressure was then restored and the gas ionized by admitting X-rays through the thin aluminum lid of the gas chamber. The next expansion, chosen sufficient in amount to cause condensation on the negative but not on the positive ions, caused a copious cloud of mist which gradually settled by its own weight to the bottom of the vessel. The top of the cloud as it fell was sharply defined, and its rate of descent could be measured.

Sir George Stokes many years before had calculated the rate of fall of small spherical bodies through air and one needed to know only the density of a small sphere and its rate of fall to compute its size. The approximate volume of the individual drops could thus be found. The quantity of water in the whole shower could also be easily determined, hence the number of drops, equal to the number of negative ions upon which they might form, could be calculated.

In another way Professor Thomson could measure the total quantity of free negative electricity present in the chamber when the fog was precipitated. He had thus the number of negative ions and the sum of their charges, and therefore the charge each carried.

The charge Professor Thomson found as the result of his brilliant experiment was the atom of electricity over again. After this it was impossible to escape the conclusion

that the bodies flying in the cathode stream were masses no greater than the one one-thousandth part of the hydrogen atom. Thus matter, or electricity, or something exists, which measured by inertia is a thousand times smaller than the lightest known atom of matter. Furthermore the kind of gas in which the cathode discharge took place had no effect upon either the charge or the mass of the particles, which bear no observable earmarks to reveal the kind of matter out of which they come. Whatever their source they are always the same.

So far as we now know the cathode particle or negative electron is a minute portion of pure negative electricity, wholly free from matter. An atom of electricity, and nothing more. Its small inertia can be wholly explained to be of the kind electric charges borrow from the ether which surrounds them.

When electrons driven at high speeds down the cathode stream are suddenly stopped by striking a target of dense matter like platinum, the point where the target is struck becomes a source of X-rays. We have already seen that a moving electric charge when brought to rest sends out a pulse of electro-magnetic disturbance in the surrounding ether, and the greater the suddenness with which the motion is arrested, the sharper and more abrupt is the shock to the ether.

In one sense the principal difference between X-rays and the yellow light from a sodium flame is analogous to the difference between the air disturbances caused by an irregular jumble of sharp thin reports of small percussion caps, and the droning of a heavy organ pipe. One is a tangle of single shocks, the other a steady wave motion. Thus regarded, nearly all the remarkable properties of X-rays find a reasonable and easy explanation.

Turning now to the positive terminal of the tube: Under suitable conditions of experiment it is possible to get a

stream of particles from it. Named as children are before their natures are in the least understood, these rays were called "canal rays." Like cathode rays they consist of flying missiles, but carry positive instead of negative charges. Compared with cathode rays their speed is very moderate and the ratio of charge to mass is of the same order as that for the lighter atoms in conduction through solutions. This ratio varies somewhat with the kind of gas in the tube. Thus canal rays are probably a stream of material atoms which have lost one or more negative electrons.

All efforts to obtain a charge of positive electricity free from matter—a veritable positive electron—have thus far failed.

The extreme complexity of the material atom is strikingly shown by the light from incandescent gases and vapors. When examined by the spectroscope the single element iron exhibits hundreds of definitely placed bright lines in the visible spectrum alone, which means the iron atom must be capable of vibrating in hundreds of different periods. No single atom need be vibrating in all these ways at the same instant, but if all iron atoms are alike, and we have every reason to believe they are whether shining on earth or in the stars, then every atom of iron must be capable of swinging or bounding, revolving or shuddering, or doing something in all these ways.

Before the evidence of the spectroscope the older idea of the atom as a simple structureless body falls to the ground. The complexity of a grand piano seems simple in comparison with the iron atom. But spectroscopic evidence does not end here but indicates what it is in the atom which does something and how it does it.

Ten years ago Professor Zeeman placed a sodium flame between the poles of a powerful electro-magnet and examined its light by the spectroscope. He observed the most striking and peculiar effects of the magnetic force on the

character of the light. The time is too far gone to permit a description of what the effects were, but the light sent out by the flame showed exactly the characteristics which magnetic force would produce, provided the light came from atoms inside which minute electric charges were rapidly revolving. It was even possible to compute the ratio of charge to mass for these revolving mites. The ratio revealed was that previously obtained for the cathode particle.

Hence the mechanism which enables the material atom to emit light is the same electron we met flying through the vacuum tube, now revolving in an orbit about the atom center as a planet revolves about the sun. Thus the chief difference between the atoms of one chemical element and those of another, may lie in the number and arrangement of electrons in a revolving system.

It had long been known that hints about the internal fabric of the atom would be most effectively sought with the spectroscope, but we have here gained at a single bound the most amazing insight into a most complex system. Here also we meet another of those astonishing previsions of Faraday. He tried Zeeman's experiment over fifty years ago, but was balked in his quest by the inadequacy of the instrumental equipment of his day.

The quite recent discovery of the wholly new and unsuspected property of radio-activity in a group of heavy elements has done much to confirm the views already expressed of the connection between electricity and matter, and much more, for radio-active phenomena suggest for the first time that some kinds of matter are not only unstable, but mutable.

Taking radium as the most highly developed example of its class, we find it, with the help of its numerous progeny, sending out three distinct types of rays which for convenience of classification have been called α , β and γ -rays.

α -rays closely resemble canal rays. They carry positive electric charges and possess a mass or inertia comparable with that of the helium or hydrogen atom.

β -rays appear identical with cathode rays. They consist of negative electrons hurled out at speeds as great as nine-tenths the velocity of light.

γ -rays are of the nature of X-rays—a purely ethereal phenomenon. All these rays penetrate matter to varying depths, and absorption varies with density as in cathode rays.

α , β and γ -rays, all have the power of wrenching electrons free from substances which absorb them. By their power to ionize gases a wholly new method of chemical analysis has sprung up—the method of analysing by the electroscope. So marvelously delicate is this new radio-analysis that one part of radium in one-hundred-million-million parts of uranium cannot escape detection. The electrometer test for differentiating the various radioactive substances is the time required for the fresh product gained by chemical manipulation to lose half its ionizing power. This important characteristic of each substance is disparagingly called its *rate of decay*.

By the aid of the new analysis, Rutherford and others have found that radium is slowly disintegrating into radium emanation, which in turn changes into a distinct substance called radium A, and so on by successive steps down the alphabet to radium F, which is possibly a parent of lead. Helium appears also as a by-product of radium disintegration. From radium downward each of the seven substances has a characteristic rate of decay ranging from 1800 years for radium, to three minutes for radium A. Radium emanation is a gas which liquifies at -150° C. Some of the later products seem to be solids.

Is it not amazing that any of the properties of these six derivative products should be known at all, when never

yet has one of them been seen, nor weighed, nor caught for direct examination?

Not only has radium offspring down to the sixth and seventh generation but it apparently has ancestors as well. It is only a link in a genealogical chain. The probable discovery of radium's immediate parent was published less than a month ago by Boltwood. Uranium is thought a remoter ancestor, possibly a great-grandparent.

Accompanying the atomic disintegration of radio-active substances large quantities of heat are evolved showing vast stores of energy hitherto unknown inside the atom.

The most reasonable explanation yet offered of the observed radio-active phenomena indicates that the complex system of electrons revolving at enormous speeds within the atom gradually loses energy until the configuration becomes unstable. A sudden readjustment takes place—a kind of internal explosion by which electrons or α particles, or both, are hurled out. The atomic structure thus relieved starts life as a new substance with a lower atomic weight. Later the new substance for a like reason again becomes unstable, another explosion occurs, and an atom of yet another substance is born.

If this interpretation of the evidence be accepted a conclusion of vast importance may be drawn. We have, we cannot say going on before our eyes, but we may say in a sense going on under our hands, a slow evolution or transmutation of matter. This conclusion is not accepted as yet without reserve for it strikes too deep at one of the assumptions of our older knowledge. Material atoms have long been thought of as immutably fixed for all time, but so were animal and plant species before Darwin. The growing evidence for this larger view of matter, though recent, is already too strong to be longer ignored. The burden of proof is gradually shifting, and to Alice's question "Why?"

comes back the equally pertinent "Why not?" of the March Hare.

To gather a little together for the closing:—The electron has but a thousandth part of the inertia of the lightest known material atom, and this inertia it doubtless borrows from the kindly ether and does not hold in its own right. Its behavior is that of an atom of negative electricity pure and simple. Its form is spherical and not spheroidal. Its size is probably less than one ten-million-millionth of an inch. When revolving briskly enough in an orbit within the atom it gives us colored light of highest purity. When violently jostling irregularly about it gives us white light, without it all light would be impossible.

We believe we have found electricity free from matter but never yet matter free from electricity. Finally comes the suggestion that matter no less than life may be undergoing a slow but endless evolution.

Some of these things and many others have led physicists to suspect that if all electricity were removed from matter nothing would be left, that the material atom is an electrical structure and nothing more.

There are however many stubborn questions to which answers must somehow be found before the so-called electron theory of matter can be accepted unreservedly. As it stands it is at once a most brilliant and promising hypothesis but has not yet reached the full stature of a theory.

Should it hold good the material atom with its revolving electrons becomes the epitome of the universe. The architecture of the solar system and of the atom, the very great and the very small, reveals the same marvelous plan, the same exquisite workmanship. The conservation of energy becomes an ethereal law and the ether the abiding place of the universal store of energy.

To end as we began, we have matter and electricity which some day may be one, and ether and energy. Of

these we hope sometime to build in theory, a reasonable world to match the one we now so little understand.

When all the interrelations among matter, ether, electricity are separated out and quantitatively expressed, we believe our work will be complete.

Such then is the confession of faith, the very far distant hope of the modern physicist.

ASTRONOMY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
NOVEMBER 6, 1907**



ASTRONOMY

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New York

THE COLUMBIA UNIVERSITY PRESS

1909

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Set up, and published January, 1908.

ASTRONOMY

THE present condition of astronomic science is a subject too extended to be brought easily within the limits suitable to this occasion; and yet it seems to me pertinent to begin with a seeming prolixity, to make an attempt at answering the question: Why is it desirable to carry on astronomic researches at all? I shall even take the liberty of entering upon this point with some particularity because I desire a test by means of which it may be possible to distinguish between genuine, and therefore desirable researches, and those undertaken mistakenly, through ignorance of any such test, or, worse still, for the mere exploitation of personal reputation and to satisfy the fetish-worship of printed publication.

Perhaps the most important element to consider in forming a judgment of any man's performance is motive. You may commit an act of forgery: it will go unpunished by the law unless a criminal motive can be proved. So I may undertake astronomic researches; I may fail totally; but my efforts will have been justified if my motive was the right one.

Now what is this motive which thus seems to me one essential pre-requisite to genuine research? In a word, it is the same as the motive of the artist. Consciously or unconsciously, the true astronomer strives ever to create a work of art. But what is art, a great painting, sculpture, music, or a monument of architecture? In the last analysis a great painting is but a smeared canvas, sculpture is a chipped

conceptions of systematic development in time, of effective change and of the long periods necessarily required were not originally, or at least not adequately grasped even by the speculative philosophers. In the general consciousness the mountains were the type figures of permanency and of unalterable resistance. Whereas, to-day, as Tennyson expresses it, we think

“The hills are shadows and they flow
From form to form and nothing stands.
They melt like mists, the solid lands,
Like clouds they shape themselves and go.”

This changed attitude toward the world of nature is one of the notable intellectual advances of the day. It has become involved with all lines of thought. From the pulpit we hear its conceptions cited. In the press the slow geological changes serve to illustrate an editorial point. And in the common speech of the people, some of its phrases have so ingrained themselves as to be almost second nature.

Broadly speaking, then, we may justly attribute to this branch of science an enlargement of our intellectual field of view, and at once a more dignified and a more elevated conception, not alone of the material universe, but of life itself.

In passing in review the problems, or at least some of them, upon which the workers of to-day are engaged, we may perhaps begin with those which bear upon the earth in its remotest stages of development, marking thus the connection of geology with astronomy and the mathematical sciences. We may then pass to those relating especially to later periods of time.

Faintly in the seventeenth century, and then firmly toward the close of the eighteenth, the general idea was gradually developed that the earth consists in its outer por-

tion of concentric strata, which succeeded one another in time of formation. The existence of a very ancient core of hard crystalline rocks, called the primary, or primitive, was demonstrated, and resting successively upon this, later ones were identified, which together built up what we summarize as the geological column. Not all of those familiar to us to-day were, however, recognized at the outset. Both at the earliest and at the latest extremes additional members have been interpolated.

Active and speculative minds were not content to think only of the times which were actually represented in the solid strata themselves, but along lines partly geological, partly astronomical, partly also mathematical, they ran back to periods still earlier. Before the eighteenth century closed and quite universally throughout the nineteenth, the earth was believed by geologists to have once been a highly heated nebulous or gaseous mass and to have passed through stages of refrigeration to its present state. This conception is the one formulated in accordance with the well-known "nebular hypothesis" and it marks, as has been stated, the connection of geology with astronomy and celestial mechanics. Grave doubts have arisen in the minds of some, however, as to its truth, and despite the significant astronomical evidence and analogies, the endeavor has recently been made by our fellow-countryman, Professor T. C. Chamberlin, of Chicago, to formulate an alternative conception, which would perhaps involve fewer difficulties. Instead of a highly heated, and subsequently cooled and solidified, gaseous original, minute particles of matter, which may have been molecules, are believed to have moved in orbits around a common center in a manner analogous to the solar system of to-day. In their evolution they became aggregated into larger bodies such as the planets and the earth, continuing in groups the motions and relations which they possessed when individuals. As the mass gradually

increased, the pressure of the outer layers consolidated the core, and by the mechanical changes involved produced those internal stores of heat with which we are familiar in volcanoes and in deep borings and mines. Vapors or liquids in the original cold particles are believed to have been gradually squeezed out by this pressure. The little particles are called planetesimals or diminutive planets, and the hypothesis is styled the "Planetesimal Hypothesis."

It is perhaps too soon to forecast the influence of this new conception upon geologic thought. Like all attempts to formulate primeval conditions, its data are partly matters of observation, partly assumptions. Speculation enters in a very large degree, and, as in the case of the various and widely differing estimates of the age of the earth based on assumed rates of cooling, once the data are provided, mathematical reasoning goes to a conclusion with unerring accuracy. But the correctness of the solution turns on the reliability of the original data, and where these are so largely assumptive the conclusions are from time to time subject to change. The field geologist, whose solutions of smaller problems turn upon carefully observed data, inevitably considers all the formulations of views regarding remote times and conditions essentially as working hypotheses, much less firmly established than many other results and to be taken much less seriously. Yet we must have a starting point, and the striking contrasts of the older and the later views cannot but impress every one who reflects upon them. The former postulates a highly heated original; the latter a cold one. The one begins with gaseous matter; the other with solid. The one draws upon an original but diminishing store of heat; the other develops heat continuously by mechanical processes. In many ways the two are diametrically opposed; yet some have raised the question, whether, in order to obtain a swarm of separate cold particles, we must not in our thought go still farther

back to a gaseous or nebulous source, and it is not clear that we have yet escaped the necessity of at least the essential feature of the nebular hypothesis.

But let us turn from these remotest and least tangible phenomena to the later ones of which we have the actual records. In all parts of the world, as we follow down through the successive layers of the fossiliferous strata, we find an ancient nucleus of crystalline rocks, gneisses, schists, marbles, serpentines, and minor varieties. The geologists who are now in middle life were quite universally taught by their instructors of twenty-five or more years ago that the old strata were all sedimentary in origin, although now thoroughly recrystallized and of vast thickness. Not a few believed that they represented materials which had been worked over perhaps many times by the ocean and the other forces of erosion. The prevailing banded or parallel arrangement of the constituent minerals was the trusted proof of their sedimentary character. But to-day when we look back we find that we have greatly advanced from these views and that we hold conceptions which much more satisfactorily fit the observations. We know that the banded arrangement of the minerals, light and dark, is not necessarily evidence of sedimentation, but that it may have been produced by a pressure, so great and irresistible as to cause the crystalline rocks to flow like viscous masses, and to drag and shear the minerals into long, parallel, leaf-like relations, suggesting indeed the bedding of sediments, but radically different from it.

While these conclusions have seemed inevitable to the observers in the field, yet at least one inquiring mind could not rest content until the processes had been artificially reproduced in the laboratory. By a brilliant piece of work and with the aid of elaborate and expensive apparatus, Professor F. D. Adams, of McGill University, has first tightly encircled cylinders of Carrara marble in jackets of

tough sheet iron. He has then submitted them to slowly, but irresistibly increasing pressure. As the strain passed their limit of crushing resistance, and while they were so tightly encased in the tough, but yielding jacket, that they could not crack, they have passed from cylinders an inch in height to discs of half this altitude and of correspondingly increased diameter. Yet they have never lost their cohesion, but have moulded themselves like so much wax. When removed from the jackets the discs are as solid and homogeneous as were the original cylinders.

These experiments are very recent, but Professor Adams is now continuing them upon other rocks such as granite; and instead of dry compression, now admits steam or heated water to the cylinder and seeks to reproduce in these respects the conditions of deep burial and metamorphism. In so far as the results have yet gone, they are a striking corroboration of the conclusions reached by observers in the field, among whom Professor Adams also occupies a most honorable place.

But we are likewise assured that banded or foliated structures may be original with igneous rocks. We have learned that molten masses in cooling and crystallizing sometimes separate into contrasted layers of light and dark colored minerals which may be brought by the conditions of eruptive flow into parallel relations suggestive of sedimentation, but different from it. The field worker of to-day upon the oldest rocks therefore constantly keeps in mind the question, am I dealing with igneous or with sedimentary types? And the general result has been to prove in the areas of the oldest rocks a series of sediments, indeed, but of greatly restricted amount and thickness as compared with earlier views, and to constantly abstract large fractional parts and prove them to be eruptive rocks which have been forced through and between the ancient sediments. Vast masses of granite and similar types are now

known, sometimes attaining dimensions of tens or even hundreds of square miles, which are later than the old limestones and sandstones, and which were regarded by our predecessors as one with them. On the whole the sedimentary antecedents of the fossiliferous strata have become much restricted in amount, and the time which they were once believed to represent has suffered diminution in a corresponding ratio.

A few moments ago the statement was made that at the close of the eighteenth century geologists well understood in a general way that the constituent strata of the earth could be classified in a systematic series of which some were older and some later. Soon after the middle of the last century the larger subdivisions were recognized which we now call periods, and substantially the same names that we use to-day were given them. Geologists knew that before the appearance of life, or in the Archean times, there were the Laurentian and Huronian periods. During the era of ancient types of life, or the Paleozoic, there were six periods, respectively, the Cambrian, Lower and Upper Silurian, Devonian, Carboniferous and Permian. During the middle era, or Mesozoic, there were three, Triassic, Jurassic and Cretaceous. During the latest era, at whose close we ourselves are living, there were two, the Tertiary and Quaternary. These eleven periods since the advent of life were each distinguished by its own types of organisms, now fossilized, and each was believed to be quite definitely and sharply outlined. If a European or an American geologist were to visit Asia or Africa, it was expected that he would find the evidence of the same times, and of periods that were contemporaneous and equivalent with those already known to him at home. This conception lasted until well beyond the student days of geologists now living. But as time went by the point of view changed and one finds to-day a much modified attitude regarding this, the very

foundation of the stratigraphic or historical portion of the subject. The old view was as if we should endeavor to co-ordinate all human history with the chronology of the Romans; whereas in China or India events were progressing without regard to Rome and of equal importance to the human race broadly considered. Multitudes of men, so great as to dwarf the numbers of the Mediterranean peoples by comparison, lived, moved, and had their being in Asia, quite unaware that a Roman had ever existed. So in geology, we have learned that while there is a general similarity of conditions over the world at any one time, yet the conditions have not been uniform and that each locality must be viewed by itself. We have all come to realize that so far from establishing contemporaneous life, identical fossils in separated localities indicate a wide difference of dates. The studies of the paleontologist lead to conclusions similar to those of the zoologist, that groups of animals or plants migrate from centers, spread abroad along belts of favorable conditions, sometimes driving out earlier inhabitants, and certainly for a time mingling with them until in the end they established colonies remote from their starting point. These migrations require long stretches of time, and radically change our old conceptions. The same species on opposite sides of the world means, therefore, not the same time for both, but a long interval between. Indeed, while in one locality organisms of a later type may be flourishing, elsewhere animals of earlier and more primitive characteristics may still be in the full tide of their activities. Just as to-day in Australia we have a fauna which is a survival of genera long since extinct in other parts of the world, so in the past, whose records have come down to us, the same contrasts have prevailed. What is Quaternary or Recent in one place, may be Mesozoic simultaneously in another.

You will see at once how much more complex is the his-

tory of the globe when interpreted in the light of the higher criticism which places the observer face to face with actual conditions, and how changed is necessarily the attitude of the geologist of to-day regarding these fundamentals when compared with that of his predecessors, and even with the views of his own earlier instructors. Turning to the future outlook, shall we anticipate as have some the passing away of our established chronology? Shall we cease to speak of a Cambrian or a Carboniferous period as world wide in its application and of fairly sharp definition? Shall we reduce ourselves to local sections each with names of geographical derivation and suited to a limited area, only running comparisons in a very general way? Some geologists have been impressed with this as the inevitable development. But others, while appreciating the limitations placed upon the old divisions and the mistaken views which followed their precise and universal application, yet see in them, when discreetly and wisely employed, the statement of a great truth. Realizing the indefiniteness of the boundaries, they yet cling to the underlying and vastly useful general application and will long continue to use the time-honored terms. The two periods of the Archean era, the six of the Paleozoic, the three of the Mesozoic and the two of the Cenozoic in not too sharp application are certain to be retained for many years to come, but the tests of their identity must be more complex and must be applied with a more comprehensive grasp of the situation.

As regards the appearance and development of life upon the earth, the two most interesting questions for the world at large relate to its beginning and to its later stages. They concern on the one side the forms which the oldest living creatures assumed, and on the other the advent of man himself. We cannot contemplate these questions without having our thinking influenced by the evolutionary doc-

trines. The first remains of life in the Cambrian strata consist of hard parts such as the shells of mollusks, which were calcareous when the animals were alive and which retain in large degree their original composition. Only resistant and enduring materials of this sort could survive through long periods of time. They indicate highly organized creatures, and are generally believed to have been preceded by ancestors of simpler types. For the remains of these ancestors, geologists have searched the older strata with the care and persistence which the importance of the question demands, since to push the evidence of life back of the Cambrian is to win one of the great prizes in geological science. But hitherto the results have been most meager. They are limited to a few indefinite tracks or questionable impressions.

Opinion, therefore, has swung around to the conclusion that the earliest organisms were marine and that they were soft-bodied animals which on death left no trace in the sediments of their time. Along two lines of attack there is a most interesting corroboration. Professor R. A. Daly, now in Boston, has been led by detailed studies in the extended series of Cambrian and Pre-Cambrian strata, along the national boundary between British Columbia and the northwestern states, to the conclusion that the Pre-Cambrian sea was devoid of dissolved salts of lime, and that, by reactions incident to the decay of soft-bodied animals upon its bottom, it was robbed of such little lime as it might otherwise have had. For a number of reasons too complicated and detailed to present here, there is good ground for believing that not until the opening of the Cambrian was sufficient lime available in the sea water to encourage the growth of those hard calcareous parts which yield the fossil remains.

Along another line of attack very interesting conclusions have been reached. Dr. A. C. Lane, the State Geologist of

Michigan, has sought to solve the problem of the composition of the oceanic waters at various periods in the earth's history by a study of the deep artesian supplies which we gain from bore-holes reaching older and older beds. From the samples of course must be eliminated contributions from higher horizons of matter not contained in the waters at the time of entombment. When all precautions are exercised we discover in the end that the oldest waters are relatively dilute when compared with the sea of to-day, and that they have but seven parts in the thousand as contrasted with the modern thirty-five. Common salt was the most abundant then as now. A very interesting connection of these researches with the problems of early life is furnished by a line of investigation pursued by Mr. R. Quinton, of the College of France. In all but the simplest organisms there is a so-called vital fluid which is the basis of the circulatory system. If, for instance, we eliminate from the blood of vertebrates or other animals the red and white corpuscles and the products of organic waste and then analyze the remaining fluid, we find a weak solution of common salt in water varying slightly in the different types, but something like seven or eight parts in a thousand. This is believed by Mr. Quinton to represent the ancient sea water in which the ancestors of all modern organisms lived and from which some forms emerged in the past. Employed as a vital medium of circulation it became enclosed in those organisms which developed the interior sack, having only communication with the outer world by osmosis, and its composition having been preserved, it recalls the early ocean, in which their ancestors originally lived. It is at least a striking coincidence that the composition of the vital medium is just about the composition of the sea as indicated by Dr. Lane for the early Cambrian or Pre-Cambrian times. If, as seems not unreasonable nor improbable, this composition, attained in

the absence of salts of lime, was particularly favorable to organic life, then the Pre-Cambrian sea may have swarmed with soft-bodied organisms. And if, with increasing land areas, more lime poured in from their drainage and the composition of the sea changed, then some animals took to the land, others developed hard parts and left the fossil remains. But in the vital medium of their circulating systems they maintained a solution corresponding to the composition of the sea water which had proved most favorable to their nourishment in the previous marine period of existence. These suggestions are at least ingenious and turn our thoughts into new and promising channels which are worthy of careful exploration.

Toward the opposite extreme in the geological record of life upon the earth lies the problem of man's appearance, a question which links geology with anthropology.

It is only upon its geological aspects that I purpose to touch, and solely of two of its phases do I desire to speak. That the general attitude of educated people toward this problem has become more tolerant in fifty years is now well realized. One may refer to the evolutionary descent and antiquity of man without, as happened in the case of the famous Calaveras skull, thereby cutting short the life of a state geological survey. We were formerly too much inclined to mix up souls and bones.

It is now forty-eight years since Darwin's "Origin of Species" was first published and thirty-six since his "Descent of Man" appeared. The last-named work squarely propounded and defended an evolutionary development from ancestors among the primates. In anatomical relations to living types there was a profound gap between man and the highest apes, most marked to the general comprehension in the sizes and shapes of the skull and brain cavity. Interest became focused upon the hoped-for discovery in some hitherto unexplored part of the globe either

of the still surviving "missing link" or else of fossil remains intermediate in type.

In the three or four decades which have elapsed since Darwin's books started investigations, no discovery of living man-like creatures of additional significance in these respects has been made; nor do we believe that such exist in the deep recesses of any unknown jungle. But in one notable instance the search for fossil remains has been more successful. On the banks of the Bengawan River, in Java, there are Pliocene or late Tertiary beds which for several years prior to 1895 were explored by Dr. Eugene Dubois, a military surgeon attached to one of the Dutch regiments. Dr. Dubois unearthed a partial skeleton of a man-like creature whose leg-bones showed that he walked erect and whose skull was intermediate between those of the highest apes and man. The volume of the brain cavity is two-thirds that of the average man, and the outline of the skull is not very different from some of the lowest types already known among prehistoric remains. Suppose that we assume a critical attitude and insist that if man existed in these times we question whether this specimen is a fair representative. We may consider it abnormal and below the average of his day. Nevertheless the presumption is strong that it is normal, since abnormal ones are the rare exceptions. Granted this, many have believed that the remains point to a separate line of descent from that of the apes, and that if we consider the fossil as indicating the ancestors of men, then the latter have come down a branch or phylum distinct from the line of the primates. We all await corroboration by more discoveries and generally anticipate that they will be made in the East, but we must admit that this Javan skeleton of *Pithecanthropus erectus* goes a long way toward bridging the gap.

As to the presence of man in relation to the great ice sheet of the Glacial epoch, it seems now fairly well estab-

lished that in Europe he was existent in the later stages. In America the evidence is less strong and abundant, and while such as we have has been subjected to much destructive, and, it would seem at times, strongly prejudiced criticism, yet there is some rather good ground for inferring that on this side of the Atlantic, as well as in Europe, primitive man was living in its closing stages. The results, however, of patient and comprehensive investigation have operated to show the great complexity of the Ice Age. Its boulders and sands are of widely different and contrasted dates. We may not rashly assume its contemporary character in separated parts of the country. Man's presence in its closing stages but reveals the long duration which went before while yet portions of North America were in the grip of extreme cold. The best we have done is to show that presumably in the later stages man was existent.

I turn from the problems of life to that other branch of geology which deals with the architecture or structural features of the earth.

Their main types and varieties have been well described and classified for many years. The labors of the Swiss, French and German geologists in the wonderfully crumpled and faulted strata of the Alps and the no less fruitful observations of the Americans in the Appalachians have established the several kinds of folds and faults, the great structural features of the sedimentary rocks.

In the regions of extinct and dissected volcanoes, moreover, and in the localities of deep-seated eruptive rocks, the records of many patient workers have taught us of the forms and features of the igneous group. The excavations of the miner have revealed both sedimentary and eruptive rocks with an accuracy and minuteness of detail not afforded in any other way. To the general conceptions now firmly established in this branch of the subject we are not

likely to add much that is new or important in kind, but within the last few years we have seen them greatly change in degree. We have long known, for example, that excessive contraction of the crust first doubles strata together, then pushes the compressed fold over on its side, and finally forces the crumpled mass along above the beds lying beyond the folded area, leaving older ones stranded upon later. In the southern Appalachians, the overthrusts have carried the beds as much as five miles from their starting points and subsequent erosion has destroyed any visible connection. With some such distances as these we have long been familiar.

But recently the European geologists have worked out cases in the Alps, where the shove has displaced the beds as much as fifty miles from their old positions. It has therefore been necessary to enlarge our conceptions by a factor of five or ten. The discoveries are new and the distances involved are so great that some time will be required in which to readjust our old-time sense of proportions, but we all realize that in these greatly compressed areas the movement was propagated along a fault plane or a series of fault planes of flat inclination which began well down in the earth's crust and which probably once continued beyond their present lines of emergence. When, however, we seek some satisfactory cause or explanation of these phenomena, both smaller and greater, we are as yet not entirely successful. The contradictory riddle of every great mountain system still confronts us. For example, we know that from New York to Alabama that portion of the Appalachians which we ordinarily call the Alleghenies consists of sands, muds, shell-beds and coral reefs, the latter two often comminuted to slimes. In the case of the sands and the muds, the materials must have been worn by the waves from older lands, presumably to the eastward. They must have been laid down in shallow waters, layer on

layer, until they became thirty or forty thousand feet thick. It is a difficult question to decide what caused the great trough to sink so gently that sedimentation nearly kept pace with subsidence throughout the long Paleozoic era. Why does the earth wrinkle downward in some localities for long periods of time and then, more remarkable still, why does it suddenly change its course and wrinkle upwards bringing the one time bottom of the sea into wave-like ridges which follow one another like so many great billows, petrified in mid-course as they roll in upon a shore. These evidences of past disturbances even more significantly than the earthquake shock of to-day lead on irresistibly downward to the interior of the earth and to the problem of its physical condition, one of the most interesting with which we have to deal and one regarding which opinions have passed through many changes in late years.

When the geologists who are to-day in middle life were students, the earth was widely believed to consist of a crust, perhaps fifty miles thick, hardened upon cooling, and surrounding a highly heated, molten core which fed the volcanoes, which admitted of adjustments and which was the still hot representative of the old incandescent nebula from which all had been derived according to the nebular hypothesis. In my own student days, the attacks of the mathematicians upon this view were beginning to be felt by the geologists. The important consideration of the rigidity of the earth, resisting deformation as it does while rapidly rotating, the lack of internal tides and similar arguments were leading to the view that a vast liquid interior was an impossibility. The effects of the pressure produced by the weight of the outer portion which rests upon the inner core and its effect in raising the fusing point to temperatures impossible of attainment were also gradually realized. A compromise view became widely prevalent. It involved the outer crust which we knew from experience

was solid, evidently to a depth measured in miles; an inner layer of fused material, intervening before the pressure became too great; and then a solid core. From the fused layer came the lava of the volcanoes. Its adjustments made the ups and down of the mountainous regions possible, and its shrinkage and that of its crust from loss of heat furnished the contractile strains which primarily caused the folds and faults. The late Professor Joseph Le Conte, for so many years the greatly beloved instructor in the University of California, was a stout defender of this conception.

But the mathematicians returned to the attack and on the principles of sound mechanics maintained with force that nothing but an essentially solid and resistant globe would survive the evident strains to which it is subject. We must believe, they have told us, that from surface to center the earth behaves with no less rigidity than would a sphere of steel. Our honored colleague of recent years in this university, Dr. R. S. Woodward, has been one of the most forceful and influential of American scientists in upholding the contention. Gradually geologists have come around to this view, but have modified it by a further conception which must be coupled with it in order to account in any satisfactory way for the evident phenomena of the mountains on the one side and the volcanoes on the other. The earth is solid, we admit; it is highly heated, certainly to very great depths; but all matter, however brittle under the conditions prevailing at the surface, becomes appreciably plastic when confined on all sides and subjected to pressures beyond its crushing resistance. Under these circumstances, rocks will flow as viscous media while losing in no respect their cohesion. In the deep-seated metamorphic rocks we see these evidences of flow, and that the flowage is possible, we positively know from the experiments of Professor Adams earlier cited.

We may, therefore, regard the interior as essentially solid, yet moving with a slow, viscous flow in any direction of less pressure. It undoubtedly is highly heated, yet it is not a molten liquid as formerly regarded. If, however, during a viscous flow toward a point of less strain the interior rises toward the surface, it is subject to less and less pressure, and inevitably in time reaches conditions under which the rocks must fuse. The vapors and gases held in all deep-seated strata are freed, and the once solid rock becomes the molten lava with which we are familiar in volcanic eruptions. Volcanoes mark, therefore, at least in their inception, restricted areas in the upper world of such low or eased pressure that toward them the deep-seated rocks pass until they can flash into a molten and even explosive condition.

But there are some further interesting features which are displayed by the volcanic centers. We often find cases where practically the same vent has been active for a long period of time, yet where it has furnished successive varieties of lava in a more or less regular series. Rocks of intermediate composition are usually the first to appear. They yield on analysis fifty to sixty per cent. in silica and their specific gravity is of mean values. They are followed by others successively higher in silica and of lighter specific gravity. Then appears a marked drop to the last out-breaks of rocks, low in silica, high in iron and related bases and of relatively great specific gravity. Thus we have what Baron Ferdinand von Richthofen called many years ago "the natural succession of the volcanic rocks." Increasing experience has shown that we must admit some variation in the regularity of this series, and that there is sometimes a recurrence to the first variety, but, on the whole, the general succession holds good and involves an important truth. In order to account for it, we have come to believe in temporary reservoirs at depths not so great as

to preclude fusion and in which the molten rock stands liquid for long periods of time. An original homogeneous mass then breaks up or differentiates into fractional parts. The lightest or most siliceous rises to the top, the heaviest or most basic sinks to the bottom. Successive eruptions are marked first by a rock of medium specific gravity and chemical composition, next by those lighter and lighter, or higher and higher, in silica as the upper layers are tapped off, finally closing with the heavy, basic dregs or settlings of the molten mass. The extinct volcanic areas of Nevada and Arizona have given fruitful evidence upon this point, and where the original type of rock reappears after its normal period has passed, we have concluded that renewed viscous flow has fed again the reservoir from more deeply seated stores.

The phenomena of volcanoes, the increasing temperature as we descend in mines, or as we test deep bore-holes with self-registering thermometers as has been done most of all in America by our Professor Hallock, together with other less familiar phenomena which I do not cite, have all led us to the belief that the temperature of the earth continues to increase as depth grows greater. This conclusion is fundamental to some of the points just made, and is probably well justified. But as regards the profound depths the rate may not hold. Some mathematical students of the subject have reached the conclusion that the rate falls off greatly, and, regarding this, opinions may be said to differ, but there is no good reason to doubt that at least for relatively great distances the interior is highly heated.

Volcanic phenomena and the problem of the interior heat have been the objects of greatly increased interest in recent years because of the remarkable and destructive outbreaks in the lesser Antilles and from Vesuvius. In two particulars, Mont Pelée in Martinique has added phenomena previously unfamiliar. The descending blast of heated gas

that wrecked St. Pierre with its tens of thousands of people was on a scale not formerly observed, and by its destruction of life aroused human sympathy as well as stimulated scientific research. The subsequent protrusion of the extraordinary spine of solid yet highly heated lava from the crater gave a striking illustration of a mass of rock passing upward in a viscous state, then solidifying before it emerged, but remaining red hot and steaming after it projected above the surface. Unfortunately it has fallen away and no longer stands as a monument to the dead buried at the foot of the cone.

There is one very recent suggestion regarding the problem of internal heat, with its corollaries, the volcanoes and the earthquake. It is the possible bearing of radio-activity. The recent discoveries that certain rare elements or so-called elements pass through a series of changes, ordinarily described as "breaking down," into other substances with the parallel development of heat, and the further discovery of the radio-active character of the volcanic rocks and their emissions, have brought prominently before our minds the possibility that herein lies a cause of the internal heat and of the emitted lavas. The idea is so new that it is as yet little more than a suggestion, but we all realize that it may be fraught with important consequences for the future and its development in the years lying immediately before us will be watched with intense interest.

It has been impossible to pass in review the topics hitherto treated without constantly introducing the idea of time, and of time so indefinite in character that we describe it as geological in distinction from the usual measurable durations. Geology brings us irresistibly face to face with stretches inconceivably long which elude our grasp as do the distances of the astronomers. Some bold mathematical spirits have sought to calculate the age of the earth from the assumed nebulous conditions to the present. The re-

sults have varied from twenty millions to several hundreds of millions of years. Perhaps one hundred millions is generally accepted as a fair attempt at a solution upon such uncertain data. If we drift away from the nebular hypothesis, we lose even these data and must attack the problem along new lines. If Dr. A. C. Lane succeeds in establishing from his samples of deep well water the composition of the Pre-Cambrian sea, and if we can calculate the rate at which rivers have poured their dissolved salts into the ocean, then we may attain an approximate idea of the time period required to raise the ocean to its present concentration.

With all these very long durations, great uncertainty is involved. Better success has been met with smaller ones, and in several cases the solutions attain much interest. The Falls of Niagara have furnished on the whole the most significant instance, and the one upon which the greatest efforts have been expended. We can but wonder if when Father Hennepin looked upon them in 1768 and felt overwhelmed, as he tells us, with the tumult of the waters, the thought did not pass through his mind as to the length of time during which the river had been at work since the crest was seven miles away toward the north. The question looks so simple at first glance that it seems as if it were merely a matter of arithmetic to observe for a time the rate per year of the recession and then divide this into the length of the gorge. If the recession is two feet per year, and the gorge is seven miles long, something like 18,000 years would be required. But we have learned that there are a number of uncertain factors. While the American Falls may retreat less than a foot per year, and even for ten years at a stretch draw back less than two inches annually, the Canadian Falls after ranging about two feet for many years may average five for five years running. The crest is now very broad; yet obviously it has been much narrower

throughout the greater part of its history. At the Whirlpool Rapids we find an older channel, one antedating the Glacial epoch, which must have headed once somewhere up stream and which can be followed out to the north. Thus, the Niagara River, as we know it on the retiring of the great ice sheet, found a part of its gorge already cut. The part was probably a modest fraction, but we have no means of determining exactly how much. It has also been demonstrated that below the Whirlpool Rapids, at what is called the Foster Flats, the river ran in a narrow western and broad eastern channel with a small island between, much as now, but on a different scale. Still, making all allowances for these facts and variations, and recognizing that the present Niagara began its work when the continental glacier in retreating uncovered its drainage area and outlet, we generally believe that not less than 10,000 nor more than 50,000 years have elapsed.

Within the last few years geologists have been impressed with the line of attack furnished by measurements of radio-activity. It has been shown that not only eruptive rocks, but also both the waters and the surface deposits of up-rising, deep-seated springs display these phenomena in determinable degrees. In the latter case the radio-activity of freshly deposited material is the greatest, and from this condition the amount falls off at a fairly well-understood rate per year. If an observer, for instance, in the Yellowstone Park determines the radio-activity of freshly-deposited calcareous matter at the Mammoth Hot Springs, and then makes a similar determination on ancient incrustations at the base of an abandoned terrace, the lapse of time since the latter began is within his grasp. In this way we have learned that a thousand years ago a certain deposit began on the glacial drift, and with more determinations of a similar character we may learn when these hot springs first began. The method is very new, but promises results both

of importance and of general interest. So new is it that at the moment we are better able to mention its possibilities than to give results *in extenso*.

Geology touches human affairs most closely on the side of mining and related enterprises, and there is no more interesting chapter in its history than the one relating to these services. Mining is a very old occupation. Civilization could scarcely advance without the aid of the metals, and modern civilization owes one of its greatest debts to coal, the common source of power.

When, however, an engineer is face to face with the actual problems of removing these materials from the earth in the most economical way, and when he must plan such operations for a period of years, it is fundamentally necessary that he should have correct geological conceptions of their origin and structure. That our usual coal seams are ancient accumulations of vegetable tissue, deposited under quiet waters in the long course of swamp growth, no properly informed person can longer doubt. That they have then been folded, often faulted, and always eroded until we have but the remnants of their past extent, admits of no question. The simple facts and principles of structural geology lie at the foundation of this branch of the mining industry and have been long established. Nevertheless, as to the exact processes which have brought carboniferous or cretaceous muck, peat and lignite along the road to the distant goal of anthracite, we are yet in debate. That the original plant tissue of the anthracite seams was so long exposed before burial under the sediments which followed hard upon it that it had lost the greater part of its volatile constituents and readily become the dense, hard, smokeless coal which we in the East so much prize, is the acute suggestion of Professor Stevenson, of our sister university here in New York, and his explanation fits the Pennsylvania case much better than any other which has been

made. Yet not a few are pondering the question, and some think that a more open-textured cover of rocks has permitted the gases incident and necessary to the change more freely to form and escape in the anthracite areas than in the bituminous. Some, again, think that the mechanical heat produced in folding, or the interior heat of the earth made available by relatively deep burial under later strata, or the neighborhood of lower lying but as yet undiscovered eruptive rocks with their stores of heat, have brought about the changes. Upon this problem many are therefore still disposed to ponder.

Again, speaking of coals both bituminous and anthracitic, we may question as follows: Were they once leaves, twigs, branches and woody tissues generally, or were they largely spores of cryptogams? If we also admit to our field of view the interesting group which embraces the cannels and the exceptionally gaseous coals, from which to this day illuminating oils are distilled in Scotland and in New South Wales, we may ask: Were they enriched with animal matter such as fish, making them fry and sputter in our grates like so much fat; or were they due to the enormously rapid multiplication of fresh water algæ in a single season, as Professor Bertrand, of Lille, has inferred from his microscopic studies of the Franco-Belgian occurrences? If this is true, then for these coals our old ideals of slow accumulation and protracted time are unnecessary, and carbonaceous deposits may have gathered with a rapidity of which we have had no proper grasp. And then there are the strange asphaltic coals which fill the fissures across our strata of sandstone and shale; representing thus the inflow of long extinct petroleum springs, now evaporated and oxidized to a shining black residuum—vein fillings they are, analogous to those metalliferous deposits to which I shall shortly pass. They connect the coals with petroleum and natural gases and lead us to ask: Whence came the

oils that gave rise to them and to our subterranean pools which have so long remained stored up in the liquid form awaiting the drill? Are they, too, fractional products from long-buried plants and animals, gradually emitted during decomposition or gentle distillation, as almost all of us in America believe; or are they outgivings from molten rock which has never reached the surface and which has been forced to steam and fume in the confinement of the lower world? A few observers urge this view and a still smaller number, mostly laboratory workers, without the steadying influence of field experience, have suggested that there are inner zones of the earth composed of metallic carbides, or even of metallic alkalies to which waters charged with carbonic acid and atmospheric air penetrate and are there changed into petroleum and natural gas. These latter are views flatly contradicted and rendered impossible by the assured physical condition of the interior.

From asphaltic coals in fissures and veins, we pass to the metalliferous minerals in similar relationships. Always when we speak of veins, the precious metals more especially fill our field of view, and what romantic and fascinating chapters in human history they suggest! We mining people think that from the time when primitive man realized his need of metals, no influence in the world's history has been so potent to cause migrations as the desire to find the silver and the gold of new countries. The Spaniards certainly came to North, Central and South America chiefly to gain them. The Englishmen hastened in droves to Australia. Occidental and Oriental alike formed the mad rush to California. The stolid Dutchman of South Africa was swamped by the flood of English, German, French and American gold-seekers on the Rand. Nor in our own day could the icy barrier of Alaskan cold stave off the tide of fortune seekers. We sometimes think that in the settlement of this staid and sober part of America the

longing for religious or political freedom almost solely brought the settlers. But the legends of the old silver mines still linger in the Highlands of the Hudson, and the hills of New England do not lack shafts and pits now long gone to ruin. Who will say to what extent these monuments to dead and buried hopes may not indicate the alluring influences of gold and silver in the unknown wilderness.

Ibsen has well said in his little poem, "The Miner":

Break in thunder, wall of rock,
At my hammer's tempest shock.
Myriad voices of the mine
Call me to its inmost shrine.

Glistening spirits beckon me,
To their sunless treasury,
Veined gold, all burning bright,
Diamond and chrysolite.

What though darkness be my lot,
Strike my hammer, falter not,
What though every hope be vain,
Strike my hammer, strike again.

Wherever rich enough to mine, the metals are found in a greatly concentrated state as compared with the earth at large. They so often fill crevices which traverse the rocks as veins cross the human hand, that the name vein has long been applied in this connection. The figurative use of the word is also happy, in that the metallic minerals, as well as their associates of no value, have been obviously brought to their resting places by circulating waters, which in the miner's phrase have nourished and enriched the crevices as does the blood the body. The veins again are, as it were, wounds or gashes in the earth which have been healed by the circulations. That water has accomplished the task few doubt. The earlier observers were accustomed to attribute

the subterranean waters to the rainfall, and, until recently, all of us who have specially studied these phenomena have fallen in with the same view. From the clouds the rains descend upon the earth's surface. In part they run off in the streams; in part they evaporate, and in part they pass into the ground, where for ages they have accumulated as the ground-water and where they constantly renew the supply. The ground-water fills our wells, pours into the shafts of our mines as we sink and forces us to pump. It stands beneath almost all parts of the surface, at depths depending partly on the amount of rainfall and partly on the nature of the rock. We formerly believed that the ground-water continued downward in the crevices of the rocks to great depths, far enough in fact to come under the influence of the internal heat of the earth, and that it was set in circulation partly by this and partly by the heat afforded by those portions which, entering the ground on the heights, forced up the shorter columns after a greater or less underground journey. In the depths where heat and pressure were influential the waters were believed to be active solvents, and in their wanderings through the narrow pores and spaces of the rocks they gathered up the metallic and non-metallic minerals and deposited them in the veins when they rose to higher levels. In the journey toward the upper world diminishing heat and pressure led to precipitation of dissolved contents. In former years we had no very definite conceptions of accessible depths, but the mathematical analysis of Professor Hoskins, of the University of Wisconsin, combined with the geological observations and reasoning of President Van Hise, of the same institution, has shown that cavities become impossibilities in the softer rocks at say 500 meters, and in the most resistant at or about 10,000. That is to say, under the irresistible crush of the overlying column, rocks hard or soft weld together into a solid mass. Circulating waters

descending from the surface must be limited to these depths as the extreme.

But in the shafts, which are rapidly exploring lower and lower rocks in many localities and are changing inferences to observation, the experience of the miner has shown that in regions remote from recently extinct volcanic activity the ground-waters end at a comparatively shallow distance. If while the shaft goes constantly downward the miner impounds the waters encountered at the upper levels, he meets no more below a thousand or fifteen hundred feet. But the veins are known in many cases to continue certainly to three times this depth, and we have been forced to cast about for some other source than the rainfall for the subterranean circulations which have originally brought in the ores. Other waters have been suggested by two chief facts of observation. Whenever the volcanoes break forth in eruption, clouds and clouds of steam and other gases go violently into the atmosphere, and when the lava wells upward from the vent and pours abroad over the crater slopes and surrounding country, it steams for many months before it is exhausted of its dissolved vapors. Molten rock in the depths of the earth must be well-nigh saturated with the pent-up gases, which are only held in check by the surrounding envelope of the crust. We have even thought, with much reason, that the steam given forth by eruptive rocks in early stages of the earth's history has condensed as the oceans, and that thus the oceans have been derived from the volcanoes, not the volcanoes caused by the percolating oceanic waters according to the more popular view. The vapors or raw materials for subterranean waters are therefore certainly in the reservoirs of interior molten rocks.

The second significant point is that in almost all of our mining districts where the operations are based on veins, eruptive rocks are a marked feature. In many there

seems no escape from the conclusion that they are in some way intimately associated with the formation of the veins which have come in as the end-product in their expiring activity.

Thus a very large proportion of mining geologists, and an even larger number of mining men accustomed to deal with the familiar phenomena of western ore-deposits, have swung around to a belief in the waters from the eruptive rocks as the agents and vehicles of deposition. Even the prospector looks upon the eruptive dike as one of the best guides in his searching. When, therefore, a mass of molten rock charged with its burden of dissolved vapors and gases rises from the depths, and stops without reaching the surface, it slowly cools, congeals and emits the vapors as the source of the mineral bearing waters which continue onward to the upper world. They start highly heated, and under great pressure. The *vis a tergo* is enormous. They constantly cool as they go and the pressure diminishes. The dissolved minerals precipitate upon the walls of the fissures, quartz and gold, in one region, silver ores with copper, lead or zinc in another. Layer on layer they grow, until the water course is choked or the fires below burn out, the steam pressure falls, and the circulation ceases. Water on the surface now begins its work, the rocks are worn away, the fragments of the vein roll down the mountain side and form the trail, which, catching the eye of the prospector, guides him to the outcrop.

In formulating this brief statement I am not unmindful of the uncertainties involved, nor that we have launched out from the facts and realms of actual observation into the profounder depths which we cannot attain. And yet by growing experience these views are found to fit the case in a satisfactory way, and our philosophical ponderings on the subject are consequently fraught with fewer difficulties and contradictions than before.

There have been advances in other branches of the subject upon which I may not dwell in the short space of an hour. Geology applied to geography under the now current term of physiography has given old facts new meaning; has made the dry bones assemble again to a living organism. Political boundaries, the distribution of races, often the turning points of history are conditioned by some mountain barrier or are due to some plain or river. The relief of the surface, the upheaval of the mountains, and the erosion of the valleys are now recognized as powerful factors in the history of mankind. The patient labors of many geologists for a century and a half in recording and studying their causes and describing their characters have borne fruit of unexpected richness and quality.

But has geology made no broad and general contributions to human thought and life? Surely when we pause for a moment and reflect upon the changes through which our views of the earth and its development have passed in the century and a half now closing, we must admit that its influence has been enlarging and beneficial. Recall if you will the gross ignorance that prevailed about the age of the earth; the ridiculously insufficient conceptions of time; the idea that fossils were the sports of nature, the *lusus naturæ*, entombed in the rocks to deceive or amuse mankind; the failure to grasp the plainest lessons of geological structure; and the absurd positive notions of the earth which once prevailed. Then we realize that into the mind of every man of even ordinary education and reading has come a flood of new light. The earth is viewed not alone in a way that is more correct and nearer the truth, but more dignified and stimulating.

When, in the striking and suggestive lecture with which this course opened and which made us all sit up and think, Professor Keyser described the inner world of the spirit to which the mathematically inclined may retreat, he awoke a

vibrant chord in many minds. Doubtless there were others besides the present speaker who harked back in their memories to old student days with the higher mathematics, when in the Elysian fields of pure thought, oblivious to space and time, comforted perhaps in affliction, absorbed and indifferent even to pain, they roamed in association with the great minds of the past. It seemed like a glimpse into the golden age or better still a vista into those future realms of the spirit toward which we now and then turn our longing eyes.

Has geology nothing similar to offer? I think it has although in a different way. Not to the realms of the inner spirit may we turn, but abroad, comprehensively, over the face of nature. Under the guidance of this branch of science we see the long and stately panorama of the past unfold. Mountains rise and disappear; sea and land repeatedly change places. Majestic forces in orderly succession perform their work, and development, whose course we may follow and whose processes understand, is made clear before our eyes. We feel ourselves as it were upon some mountain summit looking ever away and away into regions beyond. And just as when standing amid such surroundings we have felt the ecstatic thrill brought by the expanding prospect and have burned with eagerness to penetrate the new lands farther on, so in the realm of geological thought we look back over the periods of the past, over the course which we have come, over the problems solved, the lower summits climbed, and then turning ahead to the future, to the yet unknown, we burn with eagerness to push forward in our day and generation the boundaries of knowledge another stage.

BIOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
NOVEMBER 20, 1907**



BIOLOGY

BY

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**PROFESSOR OF ZOOLOGY
COLUMBIA UNIVERSITY**

New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published March, 1908.

BIOLOGY

I MUST at the outset remark that among the many sciences that are occupied with the study of the living world there is no one that may properly lay exclusive claim to the name of Biology. The word does not, in fact, denote any particular science but is a generic term applied to a large group of biological sciences all of which alike are concerned with the phenomena of life. To present in a single address, even in rudimentary outline, the specific results of these sciences is obviously an impossible task, and one that I have no intention of attempting. I shall offer no more than a kind of preface or introduction to those who will speak after me on the biological sciences of physiology, botany and zoology; and I shall confine it to what seem to me the most essential and characteristic of the general problems towards which all lines of biological inquiry must sooner or later converge.

It is the general aim of the biological sciences to learn something of the order of nature in the living world. Perhaps it is not amiss to remark that the biologist may not hope to solve the ultimate problems of life any more than the chemist and physicist may hope to penetrate the final mysteries of existence in the non-living world. What he can do is to observe, compare and experiment with phenomena, to resolve more complex phenomena into simpler components, and to this extent, as he says, to "explain" them; but he knows in advance that his explanations will

never be in the full sense of the word final or complete. Investigation can do no more than push forward the limits of knowledge.

The task of the biologist is a double one. His more immediate effort is to inquire into the nature of the existing organism, to ascertain in what measure the complex phenomena of life as they now appear are capable of resolution into simpler factors or components, and to determine as far as he can what is the relation of these factors to other natural phenomena. It is often practically convenient to consider the organism as presenting two different aspects—a structural or morphological one, and a functional or physiological—and biologists often call themselves accordingly morphologists or physiologists. Morphological investigation has in the past largely followed the method of observation and comparison, physiological investigation that of experiment; but it is one of the best signs of progress that in recent years the fact has come clearly into view that morphology and physiology are really inseparable, and in consequence the distinctions between them, in respect both to subject matter and to method, have largely disappeared in a greater community of aim. Morphology and physiology alike were profoundly transformed by the introduction into biological studies of the genetic or historical point of view by Darwin, who did more than any other to establish the fact, suspected by many earlier naturalists, that existing vital phenomena are the outcome of a definite process of evolution; and it was he who first fully brought home to us how defective and one-sided is our view of the organism so long as we do not consider it as a product of the past. It is the second and perhaps greater task of the biologist to study the organism from the historical point of view, considering it as the product of a continuous process of evolution that has been in operation since life began.

In its widest scope this genetic inquiry involves not only the evolution of higher forms from lower ones, but also the still larger question of the primordial relation of living things to the non-living world. Here is involved the possibility so strikingly expressed many years ago by Tyn-dall in that eloquent passage in the Belfast address, where he declared himself driven by an intellectual necessity to cross the boundary line of the experimental evidence and to discern in non-living matter, as he said, the promise and potency of every form and quality of terrestrial life. This intellectual necessity was created by a conviction of the continuity and consistency of natural phenomena, which is almost inseparable from the scientific attitude towards nature. But Tyn-dall's words stood after all for a confession of faith, not for a statement of fact; and they soared far above the *terra firma* of the actual evidence. At the present day we too may find ourselves logically driven to the view that living things first arose as a product of non-living matter. We must fully recognize the extraordinary progress that has been made by the chemist in the artificial synthesis of compounds formerly known only as the direct products of living protoplasm. But it must also be admitted that we are still wholly without evidence of the origin of any living thing, at any period of the earth's history, save from some other living thing; and after more than two centuries Redi's aphorism *omne vivum e vivo* retains to-day its full force. It is my impression therefore that the time has not yet come when hypotheses regarding a different origin of life can be considered as practically useful.

If I have the temerity to ask your attention to the fundamental problem towards which all lines of biological inquiry sooner or later lead us it is not with the delusion that I can contribute anything new to the prolonged discussions

and controversies to which it has given rise. I desire only to indicate in what way it affects the practical efforts of biologists to gain a better understanding of the living organism, whether regarded as a group of existing phenomena or as a product of the evolutionary process; and I shall speak of it, not in any abstract or speculative way, but from the standpoint of the working naturalist. The problem of which I speak is that of organic mechanism and its relation to that of organic adaptation. How in general are the phenomena of life related to those of the non-living world? How far can we profitably employ the hypothesis that the living body is essentially an automaton or machine, a configuration of material particles, which, like an engine or a piece of clockwork, owes its mode of operation to its physical and chemical construction? It is not open to doubt that the living body *is* a machine. It is a complex chemical engine that applies the energy of the food-stuffs to the performance of the work of life. But is it something more than a machine? If we may imagine the physico-chemical analysis of the body to be carried through to the very end, may we expect to find at last an unknown something that transcends such analysis and is neither a form of physical energy nor anything given in the physical or chemical configuration of the body? Shall we find anything corresponding to the usual popular conception—which was also along the view of physiologists—that the body is “animated” by a specific “vital principle,” or “vital force,” a dominating “archæus” that exists only in the realm of organic nature? If such a principle exists, then the mechanistic hypothesis fails and the fundamental problem of biology becomes a problem *sui generis*.

In its bearing on man's place in nature this question is one of the most momentous with which natural science has to deal, and it has occupied the attention of thinking men in every age. I cannot trace its history, but it will be

worth our while to place side by side the words of three of the great leaders of modern scientific and philosophic thought. The saying has been attributed to Descartes, "Give me matter and I will construct the world"—meaning by this the living world as well as the non-living; but Descartes specifically excepted the human mind. I do not know whether the great French philosopher actually used these particular words, but they express the essence of the mechanistic hypothesis that he adopted. Kant utterly repudiated such a conception in the following well known passage: "It is quite certain that we cannot become adequately acquainted with organized creatures and their hidden potentialities by means of the merely mechanical principles of nature, much less can we explain them; and this is so certain that we may boldly assert that it is absurd for man even to make such an attempt or to hope that a Newton may one day arise who will make the production of a blade of grass comprehensible to us according to natural laws that have not been ordered by design. Such an insight we must absolutely deny to man." Still, in another place Kant admitted that the facts of comparative anatomy give us "a ray of hope, however faint, that something may be accomplished by the aid of the principle of the mechanism of nature, without which there can be no science in general." It is interesting to turn from this to the bold and aggressive assertion of Huxley: "Living matter differs from other matter in degree and not in kind, the microcosm repeats the macrocosm; and one chain of causation connects the nebulous origin of suns and planetary systems with the protoplasmic foundations of life and organization."

Do not expect me to decide where such learned doctors disagree; but I will at this point venture on one comment which may sound the key-note of this address. Perhaps we shall find that in the long run and in the large sense

Kant was right; but it is certain that to-day we know very much more about the formation of the living body, whether a blade of grass or a man, than did the naturalists of Kant's time; and for better or for worse the human mind seems to be so constituted that it will continue its efforts to explain such matters, however difficult they may seem to be. But I return to our more specific inquiry with the remark that the history of physiology in the past two hundred years has been the history of a progressive restriction of the notion of a "vital force" or "vital principle" within narrower and narrower limits, until at present it may seem to many physiologists that no room for it remains within the limits of our biological philosophy. One after another the vital activities have been shown to be in greater or less degree explicable or comprehensible considered as physico-chemical operations of various degrees of complexity. Every physiologist will maintain that we cannot name one of these activities, not even thought, that is not carried on by a physical mechanism. He will maintain further that in most cases the vital actions are not merely accompanied by physico-chemical operations but actually consist of them; and he may go so far as definitely to maintain that we have no evidence that life itself can be regarded as anything more than their sum total. He is able to bring forward cogent evidence that all modes of vital activity are carried on by means of energy that is set free in protoplasm or its products by means of definite chemical processes collectively known as metabolism. When the matter is reduced to its lowest terms, life, as thus viewed, seems to have its root in chemical change; and we can understand how an eminent German physiologist offers us a definition or characterization of life that runs: "The life-process consists in the metabolism of proteids." I ask your particular attention to this definition since I now wish to contrast with it another and very different one.

I shall introduce it to your attention by asking a very simple question. We may admit that digestion, for example, is a purely chemical operation, and one that may be exactly imitated outside the living body in a glass flask. My question is, how does it come to pass that an animal has a stomach?—and, pursuing the inquiry, how does it happen that the human stomach is practically incapable of digesting cellulose, while the stomachs of some lower animals, such as the goat, readily digest this substance? The earlier naturalists, such as Linnaeus, Cuvier or Agassiz, were ready with a reply which seemed so simple, adequate and final that the plodding modern naturalist cannot repress a feeling of envy. In their view plants and animals are made as they were originally created, each according to its kind. The biologist of to-day views the matter differently; and I shall give his answer in the form in which I now and then make it to a student who may chance to ask why an insect has six legs and a spider eight, or why a yellowbird is yellow and a bluebird blue. The answer is: "For the same reason that the elephant has a trunk." I trust that a certain rugged pedagogical virtue in this reply may atone for its lack of elegance. The elephant has a trunk, as the insect has six legs, for the reason that such is the specific nature of the animal; and we may assert with a degree of probability that amounts to practical certainty that this specific nature is the outcome of a definite evolutionary process, the nature and causes of which it is our tremendous task to determine to such extent as we may be able. But this does not yet touch the most essential side of the problem. What is most significant is that the clumsy, short-necked elephant has been endowed—"by nature," as we say—with precisely such an organ, the trunk, as he needs to compensate for his lack of flexibility and agility in other respects. If we are asked *why* the elephant has a trunk, we must answer because the animal

needs it. But does such a reply in itself explain the fact? Evidently not. The question which science must seek to answer, is *how* came the elephant to have a trunk; and we do not properly answer it by saying that it has developed in the course of evolution. It has been well said that even the most complete knowledge of the genealogy of plants and animals would give us no more than an ancestral portrait-gallery. We must determine the causes and conditions that have coöperated to produce this particular result if our answer is to constitute a true scientific explanation. And evidently he who adopts the machine-theory as a general interpretation of vital phenomena must make clear to us how the machine was built before we can admit the validity of his theory, even in a single case. Our apparently simple question as to why the animal has a stomach has thus revealed to us the full magnitude of the task with which the mechanist is confronted; and it has brought us to that part of our problem that is concerned with the nature and origin of organic adaptations. Without tarrying to attempt a definition of adaptation I will only emphasize the fact that many of the great naturalists, from Aristotle onward, have recognized the purposeful or design-like quality of vital phenomena as their most essential and fundamental characteristic. Herbert Spencer defined life as the continuous *adjustment* of internal relations to external relations. It is one of the best that has been given, though I am not sure that Professor Brooks has not improved upon it when he says that life is "response to the order of nature." This seems a long way from the definition of Verworn, heretofore cited, as the "metabolism of proteids." To this Brooks opposes the telling epigram: "The essence of life is not protoplasm but purpose."

Without attempting adequately to illustrate the nature of organic adaptations, I will direct your attention to what

seems to me one of their most striking features regarded from the mechanistic position. This is the fact that adaptations so often run counter to direct or obvious mechanical conditions. Nature is crammed with devices to protect and maintain the organism against the stress of the environment. Some of these are given in the obvious structure of the organism, such as the tendrils by means of which the climbing plant sustains itself against the action of gravity or the winds, the protective shell of the snail, the protective colors and shapes of animals, and the like. Any structural feature that is useful because of its construction is a structural adaptation; and when such adaptations are given the mechanist has for the most part a relatively easy task in his interpretation. He has a far more difficult knot to disentangle in the case of the so-called functional adaptations, where the organism modifies its activities (and often also its structure) in response to changed conditions. The nature of these phenomena may be illustrated by a few examples so chosen as to form a progressive series. If a spot on the skin be rubbed for some time the first result is a direct and obviously mechanical one; the skin is worn away. But if the rubbing be continued long enough, and is not too severe, an indirect effect is produced that is precisely the opposite of the initial direct one; the skin is replaced, becomes thicker than before, and a callus is produced that protects the spot from further injury. The healing of a wound involves a similar action. Again, remove one kidney or one lung and the remaining one will in time enlarge to assume, as far as it is able, the functions of both. If the leg of a salamander or a lobster be amputated, the wound not only heals but a new leg is regenerated in place of that which has been lost. If a flatworm be cut in two, the front piece grows out a new tail, the hind piece a new head, and two perfect worms result. Finally, it has been found in certain cases, including animals as highly organized as

salamanders, that if the egg be separated into two parts at an early period of development each part develops into a perfect embryo animal of half the usual size, and a pair of twins results. In each of these cases the astonishing fact is that a mechanical injury sets up in the organism a complicated adaptive response in the form of operations which in the end counteract the initial mechanical effect. It is no doubt true that somewhat similar self-adjustments or responses may be said to take place in certain non-living mechanical systems, such as the spinning top or the gyroscope; but those that occur in the living body are of such general occurrence, of such complexity and variety, and of so design-like a quality, that they may fairly be regarded as among the most characteristic of the vital activities. It is precisely this characteristic of many vital phenomena that renders their accurate analysis so difficult and complex a task; and it is largely for this reason that the biological sciences, as a whole, still stand far behind the physical sciences, both in precision and in completeness of analysis.

What is the actual working attitude of naturalists towards the general problem that I have endeavored to outline? It would be a piece of presumption for me to speak for the body of working biologists, and I will therefore speak for only one of them. It is my own conviction that whatever be the difficulties that the mechanistic hypothesis has to face, it has established itself as the most useful working hypothesis that we can at present employ. I do not mean to assert that it is adequate, or even true. I believe only that we should make use of it as a working program, because the history of biological research proves it to have been a more effective and fruitful means of advancing knowledge than the vitalistic hypothesis. We should therefore continue to employ it for this purpose until it is clearly shown to be untenable. Whether

we must in the end adopt it will depend on whether it proves the simplest hypothesis in the large sense, the one most in harmony with our knowledge of nature in general. If such is the outcome, we shall be bound by a deeply lying instinct that is almost a law of our intellectual being to accept it, as we have accepted the Copernican system rather than the Ptolemaic. I believe I am right in saying that the attitude I have indicated as a more or less personal one is also that of the body of working biologists, though there are some conspicuous exceptions.

In endeavoring to illustrate how this question actually affects research I will offer two illustrative cases, one of which may indicate the fruitfulness of the mechanistic conception in the analysis of complex and apparently mysterious phenomena, the other the nature of the difficulties that have in recent years led to attempts to re-establish the vitalistic view. The first example is given by the so-called law or principle of Mendel in heredity. The principle revealed by Mendel's wonderful discovery is not shown in all the phenomena of heredity and is probably of more or less limited application. It possesses however a profound significance because it gives almost a demonstration that a definite, and perhaps a relatively simple, mechanism must lie behind the phenomena of heredity in general. Hereditary characters that conform to this law undergo combinations, disassociations and recombinations which in certain way suggest those that take place in chemical reactions; and like the latter they conform to definite quantitative rules that are capable of arithmetical formulation. This analogy must not be pressed too far; for chemical reactions are individually definite and fixed, while those of the hereditary characters involve a fortuitous element of such a nature that the numerical result is not fixed or constant in the individual case but follows the law of probability in the aggregate of individuals. Nevertheless, it is possible, and

has already become the custom, to designate the hereditary organization by symbols or formulas that resemble those of the chemist in that they imply the *quantitative* results of heredity that follow the union of compounds of known composition. Quantitative prediction—not precisely accurate, but in accordance with the law of probability—has thus become possible to the biological experimenter on heredity. I will give one example of such a prediction made by Professor Cuénot in experimenting on the heredity of color in mice (see the following table). The experiment

Grandparents	AG (white)	AB (white)	AY (white)	CB (black)		
	└───┬───┘		└───┬───┘			
Parents	AGAB (white)		AYCB (yellow)			
	└───┬───┘					
	└───┬───┘					
Offspring	{			Observed	Calculated	
	AGAY		{ (White) ..	81	76	
	ABAY					
	AGAB					
	ABAB					
	{		{ (Yellow) ..	34	38	
	AGCY					
	ABCY					
	ABCB		(Black) ..	20	19	
	AGCB		(Gray) ..	16	19	
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extended through three generations. Of the four grandparents three were pure white albinos, identical in outward appearance, but of different hereditary capacity, while the fourth was a pure black mouse. The first pair of grandparents consisted of an albino of gray ancestry, AG, and one of black ancestry, AB. The second pair consisted of an albino of yellow ancestry, AY, and a black mouse, CB. The result of the first union, AG x AB is to produce again pure white mice of the composition AGAB. The second union, AY x CB is to produce mice that appear pure *yellow*, and have the formula AYCB. What, now,

will be the result of uniting the two forms thus produced—*i.e.* AGAB x AYCB? Cuénot's prediction was that they should yield eight different kinds of mice, of which four should be white, two yellow, one black and one gray. The actual aggregate result of such unions, repeatedly performed, compared with the theoretic expectation, is shown in the foregoing table. As will be seen, the correspondence, though close, is not absolutely exact, yet is near enough to prove the validity of the principle on which the prediction was based, and we may be certain that had a much larger number of these mice been reared the correspondence would have been still closer. I have purposely selected a somewhat complicated example, and time will not admit of a full explanation of the manner in which this particular result was reached. I will however attempt to give an indication of the general Mendelian principle by means of which predictions of this kind are made. This principle appears in its simplest form in the behavior of two contrasting characters of the same general type—for instance two colors, such as gray and white in mice. If two animals, which show respectively two such characters are bred together, only one of the characters (known as the “dominant”) appears in the offspring, while the other (known as the “recessive”) disappears from view. In the next generation, obtained by breeding these hybrids together, both characters appear separately and in a definite ratio, there being in the long run three individuals that show the dominant character to one that shows the recessive. Thus, in the case of gray and white mice, the first cross is always gray, while the next generation includes three grays to one white. This is the fundamental Mendelian ratio for a single pair of characters; and from it may readily be deduced the more complicated combinations that appear when two or more pairs of characters are considered together. Such combinations appear in definite series, the nature of which may be worked out by

a simple method of binomial expansion. By the use of this principle astonishingly accurate numerical predictions may be made, even of rather complex combinations; and furthermore, new combinations may be, and have been, artificially produced, the number, character and hereditary capacity of which are known in advance. The fundamental ratio for a single pair of characters is explained by a very simple assumption. When a dominant and a recessive character are associated in a hybrid, the two must undergo in some sense a disjunction or separation in the formation of the germ-cells of the hybrid. This takes place in a quite definite way, exactly half the germ-cells in each sex receiving the potentiality of the dominant character, the other half the potentiality of the recessive. This is roughly expressed by saying that the germ-cells are no longer hybrid, like the body in which they arise, but bear one character or the other; and although in a technical sense this is probably not precisely accurate, it will sufficiently answer our purpose. If, now, it be assumed that fertilization takes place fortuitously—that is that union is equally probable between germ-cells bearing the same character and those bearing opposite characters,—the observed numerical ratio in the following generation follows according to the law of probability. Thus is explained both the fortuitous element that differentiates these cases from exact chemical combinations, and the definite numerical relations that appear in the aggregate of individuals.

Now, the point that I desire to emphasize is that one or two very simple mechanistic assumptions give a luminously clear explanation of the behavior of the hereditary characters according to Mendel's law, and at one stroke bring order out of the chaos in which facts of this kind at first sight seem to be. Not less significant is the fact that direct microscopical investigation is actually revealing in the germ-cells a physical mechanism that seems adequate

to explain the disjunction of characters on which Mendel's law depends; and this mechanism probably gives us also at least a key to the long standing riddle of the determination and heredity of sex. These phenomena are therefore becoming intelligible from the mechanistic point of view. From any other they appear as an insoluble enigma. When such progress as this is being made, have we not a right to believe that we are employing a useful working hypothesis?

But let us now turn to a second example that will illustrate a class of phenomena which have thus far almost wholly eluded all attempts to explain them. The one that I select is at present one of the most enigmatical cases known, namely, the regeneration of the lens of the eye in the tadpoles of salamanders. If the lens be removed from the eye of a young tadpole, the animal proceeds to manufacture a new one to take its place, and the eye becomes as perfect as before. That such a process should take place at all is remarkable enough; but from a technical point of view this is not the extraordinary feature of the case. What fills the embryologist with astonishment is the fact that the new lens is not formed in the same way or from the same material as the old one. In the normal development of the tadpole from the egg, as in all other vertebrate animals, the lens is formed from the outer skin or ectoderm of the head. In the replacement of the lens after removal it arises from the cells of the iris, which form the edge of the optic cup, and this originates in the embryo not from the outer skin but as an outgrowth from the brain. As far as we can see, neither the animal itself nor any of its ancestors can have had experience of such a process. How, then, can such a power have been acquired, and how does it inhere in the structure of the organism? If the process of repair be due to some kind of intelligent action, as some naturalists have supposed, why should not the higher ani-

mals and man possess a similar useful capacity? To these questions biology can at present give no reply. In the face of such a case the mechanist must simply confess himself for the time being brought to a standstill; and there are some able naturalists who have in recent years argued that by the very nature of the case such phenomena are incapable of a rational explanation along the lines of a physico-chemical or mechanistic analysis. These writers have urged, accordingly, that we must postulate in the living organism some form of controlling or regulating agency which does not lie in its physico-chemical configuration and is not a form of physical energy—something that may be akin to a form of intelligence (conscious or unconscious), and to which the physical energies are in some fashion subject. To this supposed factor in the vital processes have been applied such terms as the “entelechy” (from Aristotle), or the “psychoïd”; and some writers have even employed the word “soul” in this sense—though this technical and limited use of the word should not be confounded with the more usual and general one with which we are familiar. Views of this kind represent a return, in some measure, to earlier vitalistic conceptions, but differ from the latter in that they are an outcome of definite and exact experimental work. They are therefore often spoken of collectively as “neo-vitalism.”

It is not my purpose to enter upon a detailed critique of this doctrine. To me it seems not to be science, but either a kind of metaphysics or an act of faith. I must own to complete inability to see how our scientific understanding of the matter is in any way advanced by applying such names as “entelechy” or “psychoïd” to the unknown factors of the vital activities. They are words that have been written into certain spaces that are otherwise blank in our record of knowledge, and as far as I can see no more than this. It is my impression that we shall do bet-

ter as investigators of natural phenomena frankly to admit that they stand for matters that we do not yet understand, and continue our efforts to make them known. And have we any other way of doing this than by observation, experiment, comparison and the resolution of more complex phenomena into simpler components? I say again, with all possible emphasis, that the mechanistic hypothesis or machine-theory of living beings is not fully established, that it *may* not be adequate or even true; yet I can only believe that until every other possibility has really been exhausted scientific biologists should hold fast to the working program that has created the sciences of biology. The vitalistic hypothesis may be held, and is held, as a matter of faith; but we cannot call it science without misuse of the word.

When we turn, finally, to the genetic or historical part of our task, we find ourselves confronted with precisely the same general problem as in case of the existing organism. Biological investigators have long since ceased to regard the fact of organic evolution as open to serious discussion. The transmutation of species is not an hypothesis or assumption, it is a fact accurately observed in our laboratories; and the theory of evolution is only questioned in the same very general way in which all the great generalizations of science are held open to modification as knowledge advances. But it is a very large question what has caused and determined evolution. Here, too, the fundamental problem is, how far the process may be mechanically explicable or comprehensible, how far it is susceptible of formulation in physico-chemical or mechanistic terms. The most essential part of this problem relates to the origin of organic adaptations, the production of the fit. With Kant, Cuvier and Linnaeus believed this problem scientifically insoluble. Lamarck attempted to find a solution in his theory of the

inheritance of the effects of use, disuse and other "acquired characters"; but his theory was insecurely based and also begged the question, since the power of adaptation through which use, disuse and the like produce their effects is precisely that which must be explained. Darwin believed he had found a partial solution in his theory of natural selection, and he was hailed by Haeckel as the biological Newton who had set at naught the *obiter dictum* of Kant. But Darwin himself did not consider natural selection as an adequate explanation, since he called to its aid the subsidiary hypotheses of sexual selection and the inheritance of acquired characters. If I correctly judge, the first of these hypotheses must be considered as of limited application if it is not seriously discredited, while the second can at best receive the Scotch verdict, not proven. In any case, natural selection must fight its own battles.

Latter day biologists have come to see clearly that the inadequacy of natural selection lies in its failure to explain the origin of the fit; and Darwin himself recognized clearly enough that it is not an originative or creative principle. It is only a condition of survival, and hence a condition of progress. But whether we conceive with Darwin that selection has acted mainly upon slight individual variations, or with DeVries that it has operated with larger and more stable mutations, any adequate general theory of evolution must explain the origin of the fit. Now, under the theory of natural selection, pure and simple, adaptation or fitness has a merely casual or accidental character. In itself the fit has no more significance than the unfit. It is only one out of many possibilities of change, and evolution by natural selection resolves itself into a series of lucky accidents. For Agassiz or Cuvier the fit is that which was designed to fit. For natural selection, pure and simple, the fit is that which happens to fit. I, for one, am

unable to find a logical flaw in this conception of the fit; and perhaps we may be forced to accept it as sufficient. But I believe that naturalists do not yet rest content with it. Darwin himself was repeatedly brought to a standstill, not merely by specific difficulties in the application of his theory, but also by a certain instinctive or temperamental dissatisfaction with such a general conclusion as the one I have indicated; and many able naturalists feel the same difficulty to-day. Whether this be justified or not, it is undoubtedly the fact that few working naturalists feel convinced that the problem of organic evolution has been fully solved. One of the questions with which research is seriously engaged is whether variations or mutations are indeterminate, as Darwin on the whole believed, or whether they may be in greater or less degree determinate, proceeding along definite lines as if impelled by a *vis a tergo*. The theory of "orthogenesis," proposed by Naegeli and Eimer, makes the latter assumption; and it has found a considerable number of adherents among recent biological investigators, including some of our own colleagues, who have made important contributions to the investigation of this fundamental question. It is too soon to venture a prediction as to the ultimate result. That evolution has been orthogenetic in the case of certain groups, seems to be well established, but many difficulties stand in the way of its acceptance as a general principle of explanation. The uncertainty that still hangs over this question and that of the heredity of acquired characters bears witness to the unsettled state of opinion regarding the whole problem, and to the inadequacy of the attempts thus far made to find its consistent and adequate solution.

Here, too, accordingly, we find ourselves confronted with wide gaps in our knowledge which open the way to vitalistic or transcendental theories of development. I think we should resist the temptation to seek such refuge. It is

more than probable that there are factors of evolution still unknown. We can but seek for them. Nothing is more certain than that life and the evolution of life are natural phenomena. We must approach them, and as far as I can see must attempt to analyze them, by the same methods that are employed in the study of other natural phenomena. The student of nature can do no more than strive towards the truth. When he does not find the whole truth there is but one gospel for his salvation—still to strive towards the truth. He knows that each forward step on the highway of discovery will bring to view a new horizon of regions still unknown. It will be an ill day for science when it can find no more fields to conquer. And so, if you ask whether I look to a day when we shall know the whole truth in regard to organic mechanism and organic evolution, I answer: No! But let us go forward.

PHYSIOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
NOVEMBER 27, 1907**

PHYSIOLOGY

BY

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COLUMBIA UNIVERSITY

New York

THE COLUMBIA UNIVERSITY PRESS

1909

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Set up, and published February, 1908.

PHYSIOLOGY¹

BY FREDERIC SCHILLER LEE

PROFESSOR OF PHYSIOLOGY

IN the introductory lecture of the present course we were told that ours is the golden age of mathematics. As week after week has passed by since then, we have been led from one golden age to another, convinced, for the time, that the present brilliant achievements of each science outshine those of all the others. A few days ago I found on my desk an entomological monograph, the opening sentence of which reads, "The present age is the age of insects." I shall not attempt to harmonize the declarations of my Columbia colleagues with that of my entomological friend. But I feel that I would be derelict in my devotion to my own subject, if I did not state frankly at the outset of my lecture—what ought, however, to be a self-evident truth—that the present is preëminently the age of physiology. Nor, following again the example of my predecessors, need I be over-modest in my claims as to the place of physiology in the scientific hierarchy. For Fick speaks of it as "the highest and most fruitful generalization of the collective natural sciences," and Czermak calls it "the summit of all the sciences."

It need not be emphasized that no exact boundary line exists for any one of the biological sciences. The proper domain of each extends, at its borders, imperceptibly into the domains of all, and within the boundary zones it is

¹ A lecture delivered at Columbia University in the series on Science, Philosophy and Art, November 27, 1907.

difficult to say what belongs to one and what to another. With this in mind it is impossible sharply to delimit the science of physiology. Nevertheless its proper domain is easily surveyed. Physiology deals with the process of life, the living of living substance. It is a dynamic, not a static science. The form, structure and composition of living things do not properly come within its scope: they form the subject matter of morphological, static sciences. But the changes in form, structure and composition, which are manifestations of the life process, are proper subjects of physiological study. Its material exists wherever life exists. Whether it be the growth of a man or of a tree, the creeping of an amoeba or the contraction of a muscle, the beating of a heart or the production of a disease by a bacterium, the mental activity of a brain or the response of an infusorian to light, the process of reproduction or of inheritance, the phenomena of nutrition or the behavior of an organism to changes in its environment—all of these and a thousand others are physiological phenomena and proper subjects of investigation in the physiological laboratory. It is true that many departments of learning, which essentially are branches of physiological science, have been so far specialized in the methods of their pursuit and their aims and augmented by non-physiological additions, as to entitle them to specific names. In such cases it often is not expedient for physiology to busy itself with the more remote results of the operations of its laws. The great biologist of the last century, Johannes Müller, was wont to say, "*Psychologus nemo nisi physiologus.*" But, although psychic phenomena are inextricably linked with neural processes, the right of psychology to be recognized as an entity, with the study of psychic phenomena as its prerogative, has been abundantly demonstrated by its achievements. So, too, the proceedings of human society are the resultants of the action in human beings of physiological

principles. But the study of the resultants themselves falls within the special province of the sociologist. It is thus customary to recognize as largely independent sciences, such branches of knowledge as psychology, sociology, neurology, biological chemistry, experimental zoology, hygiene, bacteriology, pathology, and preventive medicine; but in all these there is a large element of pure physiology, and their adherents often deserve the name of physiologists. When I say that the present is preëminently the age of physiology I mean it seriously, since at no time has the physiological spirit, the spirit of examining vital phenomena by the aid of experimentation, so completely permeated and vitalized the biological sciences as now.

There exist many misconceptions regarding the subject matter and scope of physiology. In the popular mind physiology deals with the life processes of the human body. In reality human physiology is but one of its many interests. It has its anthropocentric aspect. Biocentric it is in reality. The popular conception of physiology as a science of the functions of gross anatomical organs expresses, too, but a small part of the truth. During the middle part of the last century a powerful school of investigators in Germany busied themselves largely with the functions of organs, and strongly impressed the science of their time and the popular mind. But one of the pronounced phases of physiological development in recent years has been a similar rich growth of the study of the life processes of the cell. Another popular misconception is that physiology deals only with the internal parts of organisms—a view that is confuted by the fact that there is now going on much investigation of the mutual relations of organisms and their environment, in other words, an expansion of what has been called external physiology, which might bear the newer title of oecology. But the

widespread ignorance regarding the broad scope of physiology is in part explained by the fact that a large number of professed physiologists do busy themselves with, and most academic courses deal largely with, the vital phenomena of the internal parts of higher animals with the image of man ever in the background. The chief cause of this condition in turn is doubtless the rise of the science within medical schools and its continued close association with them, as a result of which the attention of investigators and teachers has been necessarily focused largely upon internal problems. This aspect of the science is mirrored in the text books, and is the chief aspect that is presented to the youth in his early studies. Unfortunately the university student has only a limited opportunity to correct his early false impressions, for the university has not yet accorded to physiology its rightful heritage as a pure science. Its freedom in research cannot be denied it, however, and popular misconceptions regarding its scope will disappear with its advance. The living of the living thing is the criterion by which the physiological phenomenon may be recognized.

The ways in which the vital process manifests itself seem at first sight numberless and incapable of mutual comparison. The contraction of a muscle, the secretion of a glandular product, the production of a sensation, the growth of an organism, the orientation of a motile body to rays of light, the passage of a nervous impulse, respiration, the circulation of blood, the transmission of a quality from parent to offspring, instinct, fatigue, a volitional act, the course of a germ disease, sleep, speech, laughter, thought, the digestion of food, the maintenance of bodily temperature, the hearing of sound, sight, the recognition by touch of a familiar object, memory, emotions, the inhibition of an existing action, hypnosis,—at first thought these phenomena appear to be of quite different kinds, each

sui generis and incapable of comparison with the others. Have they common factors? Is it possible to unify them?

Through the ages various attempts have been made to do this. The appearance of the first of these attempts was nearly coincident with the culmination of Grecian culture. From that auspicious time down to the great Roman physician Galen, then across the long stretch of thirteen centuries, bridged by Galenic tradition, but barren of physiological discovery, to the rebirth of scientific, together with other, learning, and well into the seventeenth century, the doctrine of the *pneuma*, or spirits, reigned supreme. This doctrine was often expressed in vague, uncertain terms, and in the hands of the Stoic philosophers, the Pneumatic physicians, the scientific men of Alexandria, Galen and minor writers, it was variously portrayed. The *pneuma* was believed to be an extremely subtle material agent entering the body with the breath, and was spoken of as "very subtle air," "very lively and pure flame," "fluid," "of the nature of light," "vapor," "something analogous to the spirits of wine," and so on. Each vital action was a manifestation of its activity. In the heart dwelt the vital spirits; in the brain the animal spirits. They flowed and ebbed through the veins and arteries, they coursed along the nerves, they permeated the tissues, and they bubbled and effervesced. Through them the body felt and moved, was nourished and warmed, grew and reproduced. It was a genial, comforting belief, nothing was more plausible; in its light vital actions seemed simple enough; and so for two thousand years the spirits danced merrily along.

But there were hard-headed thinkers in the seventeenth century. We may even imagine that the skilful experimenter, Harvey, the discoverer of the circulation of the blood, had his doubts. It is true that Descartes made free use of the spirits in his clever portrayal of the working of

the organic machine, but there were others, believers in the machine, who contended that its *Deus* was not the *pneuma*. The spirit of mechanism was in the air. With the beginning of a rational physics, stimulated largely by the discoveries of Galileo and Newton, and a rational chemistry, freed from alchemy, there arose those two curious groups of utopian theorizers, the iatro-physicists and the iatro-chemists, led respectively by Borelli and Sylvius. The one looked at the actions of the living being through the spectacles of the physicist, the other through those of the chemist; to the one vital actions were physical phenomena, to the other, chemical phenomena. Their gaze was in the right direction, and each believed that he saw a great light. But like the whole world of science of their time, they knew too little of the true physics and chemistry, and their interpretations of organic processes, while containing a considerable modicum of the truth, teemed with unwarranted hypothesis. It was not strange, therefore, that the iatro-movement was short-lived. Its influence, however, was not without value, for as the knowledge of physiological fact increased through experiment, and the world became accustomed to mechanical notions, the authority of the spirits became weakened, and gradually, very gradually, they ceased to be a factor in physiological reasoning. In popular speech, however, they persist even to our own day; for, as our moods change, we are in good spirits or bad spirits, full of spirit or lacking in spirit, high-spirited or low-spirited—phrases which stand as witnesses of a once powerful, but now discarded physiological doctrine.

As the spirits became deposed, scientific thinkers, dissatisfied with the mechanism of the time, still groped for something to take their place. There were spontaneous uprisings of such agencies as Van Helmont's *archeus*, Stahl's *anima*, Boerhaave's *principium nervosum*, and

Hoffmann's ether. None of these long survived, and soon after the middle of the eighteenth century they were definitely replaced and the widespread desire for a unifying principle was for the time set at rest, by the hypothesis of vital force. All physiologists had now come to realize that many of the chemical and physical phenomena of inorganic nature were to be observed also in living bodies. But they knew that the chemical composition of the latter differed from that of the former, and for the manufacture of the vital substance and for many of its actions they could find no parallel outside of living bodies. Most of them succumbed to the compelling power of their ignorance and acquiesced in the assumption that a peculiar principle resides in living things, a vital force (or energy, as we would call it to-day), differing in nature from the forces (or forms of energy) that exist in non-living things. Johannes Müller presented the vitalistic conception clearly as follows: "Organic bodies consist of matters which present a peculiar combination of their component elements, a combination of three, four, or more to form one compound, which is observed only in organic bodies, and in them only during life. Organized bodies, moreover, are constituted of organs, * * * each * * having a separate function; * * * and they not merely consist of these organs, but by virtue of an innate power, they form them within themselves. Life, therefore, is not simply the result of the harmony and reciprocal action of these parts; but is first manifested in a principle or imponderable matter, which is in action in the substance of the germ, enters into the composition of the matter of the germ, and imparts to organic combinations properties which cease at death." By the same author life is characterized as "the manifestation of the organic or vital force." Again, "Organic bodies participate in the general properties of ponderable matter. The laws of mechanics, statics, and

hydraulics, are also applicable to them." The application of these laws to them is, however, "limited, from the circumstance that the causes of motion most engaged in them are essentially vital in their nature." A few bold spirits, like Reil in Germany and Magendie in France, argued against such a conception, but they formed a small minority, and the physiology of the time became essentially vitalistic.

This state of affairs prevailed for barely a century. Soon after its beginning oxygen was discovered, and the modern chemistry was begun. A few decades more and the new physics was founded on the doctrine of the conservation of energy. These two discoveries with their momentous consequences were epoch-making for physiology. The events of the inorganic world were at last conceived by the human mind in a rational manner, and the application of such conceptions to vital processes was not delayed. The assumption of a specific vital force was seen to be unnecessary. Men began to talk of vital phenomena in terms of the new sciences, and physiology began to be defined as the science of the physics and chemistry of living things. Such is the prevailing conception to-day.

Is the vital process more than physics and chemistry? Two facts stand out strongly in the physiology of the present day. One is the constant extension of physico-chemical principles into the explanations of hitherto mysterious functions; the other the seeming inadequacy of those principles to explain other functions. In their attitude toward this apparent inadequacy physiologists, while disavowing with almost entire unanimity their belief in the vital force of a century ago, may be said to be collected at present into two camps. By far the majority, while not denying the existence of puzzling problems, are yet possessed of an optimistic spirit and look forward with

serenity to the unraveling of the mysteries of the organism, as the mysteries of the inorganic become more clear. They look at life, not as a distinct entity permeating and vitalizing a complex machine, but rather as the sum of the activities of that machine. In the opposite camp there are a few souls who, though they too have cast off the dross of the old conception, are rendered impatient and despondent by the occasional failure of present knowledge to explain, and they fly for refuge to a refined and essentially inexplicable vital residuum. They have succumbed to the inevitable reaction that follows rapid progress. But they are not vitalists, they say, at least not palæo-vitalists: they are neo-vitalists. Into the intricacies of neo-vitalistic views and into the shades of difference existing between them it is not opportune here to go, for they exert practically no influence on the physiology of the time. The hopeful investigator continues his endeavors, and with success, to interpret vital processes in accordance with physico-chemical laws. It seems to me that this is the most promising method. For less than one hundred years has it avowedly been in vogue, and these have been the years of most rapid advance. In this time many mysteries seemingly inexplicable have been clarified. It is futile to deny future rapid progress along the same lines, and the solving of problems that now defy the ingenuity of the experimenter. We confess our ignorance and our frequent failures, but we believe that we are on the right track. Physics and chemistry are not completed sciences. Their youth indeed is hardly passed. Their greatest achievements are probably yet to come. If what we know of physical mechanism to-day is not sufficient to insure us an understanding of the physiological machine, then let us look to what we shall learn to-morrow. Whatever the ultimate outcome, the solace of the vitalistic conception, it seems to me, should be resisted until we are prepared with full knowl-

edge to maintain the final inefficacy of the physico-chemical mode of interpretation. If such a time ever arrives, it must necessarily be far in the future.

If the vital process be capable of a physico-chemical interpretation, it is at once understood that the methods of the physiologist must be the methods of physics and chemistry. And this is the case. In the physiological laboratory we employ the same methods that are used in the physical and the chemical laboratories, modified only in so far as is necessary to adapt them to the material employed for study and the specific problems to be solved. Specific physiological apparatus of precision in great variety has been devised, and specific methods of using it. But the apparatus and methods are physical and chemical in essence. The physiologist's material for study must necessarily be living material, except in so far as it is possible to deduce the vital phenomenon from the phenomena of non-vital substances—a procedure which, though often necessary, as is especially the case in much of the work of the chemical physiologist, is a procedure of limited value. In external and in much of internal physiology the living organism is used intact. With many problems of internal physiology, however, the method of vivisection must be employed—a method, which, notwithstanding the occasional charges of the uninformed, does not in either its theory or its practice imply cruelty or inhumanity.

Physiology has long since passed the stage where unaided observation alone is of value, and has become pre-eminently an experimental science. It is the task of the experimenter to alter one or more of the conditions under which the phenomenon occurs, to observe its change, if such appears, and thus to throw light upon the nature of the phenomenon itself, its relation to both its original and its changed conditions, and its causes. Herein lies the enormous difficulty of physiological work. The vital process

is of a complexity unapproached, much less equaled, in the inorganic world. Living substance is never exactly the same at two successive periods. It is ever in unstable equilibrium, the seat of constant change, of augmentations and depressions, of physical and chemical mutations, and of what we in our ignorance call spontaneous activities; and the conditions of its activities are manifold and often obscure and unsuspected. To maintain the majority of these conditions intact, while altering one or more, is a superhuman task, one that is approached, but probably never realized in its entirety. The physiologist is thus constantly baffled in his pursuit of the desired object, and must needs exercise unwonted patience in the face of not infrequent failure. His progress is slow and his results can only approximate the mathematical exactness of the experimenter who deals with stable non-living matter.

Since the time when physiology assumed its physico-chemical aspect and entered upon its modern phase, what has been the trend of its research? Its energies were first directed chiefly to the study of the mechanical and other physical problems of the organs of vertebrate animals. The electrical method of stimulating living substance was devised, by which the latter can be made to act at the will of the experimenter,—a method the importance of which can scarcely be overestimated. The graphic method was early introduced and has been developed to the greatest refinement. By its use organic movements can be recorded graphically, and can then be easily analyzed into their space and time components and be studied at leisure. The working of the organs of the mammalian body, considered as physical machines, is now fairly well understood, although specific problems within this field are still being actively investigated. Very exact computations have been made of the amount of energy given off by the body in the form of heat and of muscular work, and it

has been found to correspond very closely with the income of energy derived from the food and whatever bodily material may be consumed during the experiment. The principle of the conservation of energy applies as well to the living as to the non-living machine.

Chemical physiology, or, as it is now often called, biochemistry, developed gradually during the last century but did not become prominent until the last decade. It occupies now a foremost place among the branches of biological science. Much biochemical work is morphological; the determination of the chemical constituents and structure of substance once living, from which inferences may be drawn as to the chemical nature of living substance. Unfortunately living substance cannot be chemically analyzed directly, since all known methods at once kill it, and there is left only the non-living proteins, carbohydrates, fats, and other organic and inorganic compounds, the individual bricks, or, better, cleavage products of the complex unity. In determining these and their relationships great progress has been made, but we of the present are far removed from that state of smug satisfaction of some of the earlier investigators, to whom a living body represented only so many molecules of carbon, oxygen, nitrogen, hydrogen, sulphur and phosphorus. The problems of the chemical physiologist, as distinguished from the chemical morphologist, are in general the problems of metabolism,—which the Germans have aptly styled "*Stoffwechsel*,"—the chemical changes undergone by matter in the process of living, its building up and its breaking down, its anabolism and its katabolism. The intricacies of metabolism can scarcely be conceived by one not familiar with the attempts to follow them, and the biochemists deserve much credit for the ingenuity of their methods. They have been most successful in determining and isolating the multitudinous katabolic products of vital

activity, both the intermediate and the final products, and in discovering clues to the individual steps in the katabolic process. They have even succeeded in making synthetically many of these vital products, an achievement which was inaugurated by Wöhler in 1828 in the manufacture of urea. The laboratory synthesis of vital products has become, indeed, almost a daily occurrence and has hence lost its former miraculous appearance. It is not, however, certain that the laboratory methods and the physiological methods employed in such synthesis are identical. The steps of the anabolic process are still obscure, and until they are better known, we can hardly look forward with confident satisfaction to the artificial manufacture of living substance. Yet physiological alchemists do exist, and the successful making of "life" has been heralded more than once to a sensation-loving world. Such an achievement is for the present only an idle dream, serving to gently and pleasurably titillate the cerebral cells of the dreamers.

Of recent years physiological physics and physiological chemistry have come to meet on common ground within the realm of the new science of physical chemistry. It has come to be clearly recognized that living substance consists of organic colloidal, or jelly-like, material, permeated by inorganic matter. The colloidal matter seems to consist of enormous complex molecules and aggregates of molecules; the inorganic matter partly of smaller, simpler molecules, and partly of ions, which are atoms or groups of atoms charged electrically. As the life process goes on, the living substance being now in a state of activity, now in a state of rest, there is a constant chemical and physical interplay between the two material constituents, and a constant interchange between them and the surrounding medium, in which the laws of osmosis play a prominent part. The careful investigation of the nature of these in-

ternal and external exchanges seems to be illuminating many time-honored physiological enigmas, such as absorption, secretion, excretion, and other instances of the passage of substances through membranes, the electrical phenomena of tissues, the nature of the nerve impulse, the fertilization of the ovum and the general nature of chemical changes within protoplasm—enigmas which have been constantly quoted in support of the vitalistic conception. But we should not be tempted by success along these lines to claim, as is sometimes done, that the life process is merely ionic or electrical or osmotic in nature. In investigating physiological problems by the aid of modern physical chemistry, we seem to be brought at times perilously near the electron theory of matter, and we are tempted to hazard the guess that the establishment of that theory would place the physiologist under renewed obligations to the physicist.

The study of ferments, too, is assisting—strange, innumerable, intangible bodies of uncertain nature, which, present in minute, almost imperceptible quantities, seem to facilitate vital chemical actions without entering directly into them. In the early years ferments were recognized as mediating the processes of digestion, and but few of them were known. Of late their number has been enormously increased, and a corresponding number of intracellular or extracellular chemical processes has been ascribed to their action. Each has its own specific chemical reaction to facilitate, and in many cases, at least, their action is reversible, *i.e.* one and the same ferment can aid both the decomposition of a complex substance into its constituents and the synthesis of those constituents into the complex substance. The ferments that function in vital processes are products of living matter, but recent research makes it increasingly clear that they act merely like catalytic agents of inorganic origin. The study of

ferments has its dangerous aspect, for more than one investigator, with an eye single to their universality and efficacy, has in his cyclopean enthusiasm come to suspect that all the chemical processes of living organisms are mediated by them, and has even been led to make the narrow and unwarranted assertion that life itself is merely ferment action.

The discovery of protoplasm and the establishment of the cell theory have exercised a profound influence on the science of function. Until nearly the middle of the last century physiologists were in a sense groping in the dark, for the reason that although they were endeavoring to unravel the mystery of living substance, they had no conception of the real nature of that substance. When the times were ripe they were quick to recognize the value and significance of the new discoveries, and, indeed, played valuable parts in formulating and establishing the new doctrines. With the clear recognition of a definite substance as the physical basis of life, their energies were more definitely directed than before. One result of this has been the increasing and powerful growth, during the latter part of the last century and the early years of this, of general physiology. The rise of general physiology represents a movement away from the earlier study of the mechanics of organs, toward that of the vital phenomena of living substance itself, irrespective of its special position within the organism. General physiology is pre-eminently the physiology of to-day, whether its point of view and methods be physical or chemical.

The principle of organic evolution is in its essence a physiological principle. It represents a great physiological experiment which nature has been making since the beginning of living things, and is continuing to make. But the discovery of the facts and principles of organic evolution and the establishment of its theory have been ac-

complished only in small part by professed physiologists. Not even has the evolution of function—a field of great possibilities—been explored, except in a few small and isolated spots. The necessity of properly controlled experimentation in settling the vexed problems of evolution is, however, at last being recognized, and the next few decades promise to witness great advances in the discovery of the ways in which nature has made her great experiment.

It is not strange that with its intricacies and peculiar difficulties the solving of the problems of nervous function has proceeded slowly. The facts that nervous function is a property of the nerves, and that the brain is the seat of the mind, were probably first capable of scientific proof by the Alexandrians in the fourth century before Christ. The two great functions of sensation and motion were also recognized by the ancients, but that they were mediated by different nerves was first demonstrated by Sir Charles Bell, so late as 1811. The idea of the specific energy of nerves,—a phrase which means specific activity,—or the general principle that each nerve has specific functions with which it always responds, no matter how stimulated, was definitely proposed by Johannes Müller in 1826 for the nerves of special sense, and later was generalized for other nerves and other tissues. Since then great progress has been made in discovering by experiment the specific functions of individual nerves and in formulating therefrom theories of the general functions of nervous tissues. That different nervous activities are associated with different portions of the brain was early surmised, and before the middle of the past century such important nervous centers as those controlling respiration and the beat of the heart became located. Since then the nervous mechanism of a host of unconscious organic processes has been discovered. That the psychic portion of

the brain does not function as a unit, but consists rather of a complex group of nervous organs, each with its specific functions—a fact that is of great moment in elucidating the relations of brain and mind—has been known for only a little more than thirty-five years. For it was in 1871 that Fritsch and Hitzig, by stimulating specific small areas of the surface of the cerebrum and obtaining in response specific muscular movements, first demonstrated a specific cerebral localization of functions. Since then the task of mapping out the outer layer, or cortex, of the cerebrum of a few mammals and man into centers, joined by nerve fibers with specific organs of the body and employed for the control of separate groups of muscles and for the work of the special senses, has proceeded to a considerable degree. Thus, we are now able to point to a certain portion of one of the convolutions of the cerebrum and say that its nerve-cells, or neurones, mediate the volitional act of contracting one's biceps muscle; we can say that the neurones in other localities mediate the separate acts involved in locomotion; in others, the changes of facial expression; and in still others, the enunciation of thoughts in the form of spoken words. We know with considerable exactness the positions of the separate centers for sight and hearing; less exactly those of the other special senses. Besides the sensory and motor centers, evidence points strongly toward the existence also of cortical regions which are elaborately joined to one another and to the sensory and motor regions by means of innumerable nerve fibers, and the function of which is to correlate, harmonize, or associate the work of the sensory and motor centers. Such association centers thus help to mediate the more complex psychical phenomena, such as memory and the association of ideas. We can even formulate helpful hypotheses of the neural accompaniments of various psychoses. According to James' theory of the emotions, for example, the per-

ception of the automobile about to run us down leads to the feeling of fear only through the mediation of various organic processes, such as a quickening of the heart beat, pallor and trembling. The accompanying series of neural processes would consist in the activity, in turn, of visual sense organs, neurones conveying the visual impressions to the brain, cerebral neurones mediating the sensation and perception of the terrifying car, motor neurones controlling the peripheral muscular actions that are involved in the organic processes, neurones conveying to the brain the impressions of altered heart beat, constricted arteries, and trembling muscles, and lastly cerebral neurones mediating the feeling of fear. Because of its difficulty, much of the work of geographical exploration within the central nervous system is at present necessarily inexact, and moreover there is still much *terra incognita*. And even though we have thus come to know the gross functions of specific parts of the higher mammalian and human brains, we still know all too little of the processes by which the different parts are coördinated and made to subserve the many complex needs of the organism. The recent work of Professor Sherrington on the integrative action of the nervous system, is an admirable example of the kind of investigation that is needed in this field, and by its very excellence helps to emphasize the lack of our knowledge. The laboratories of physiological psychology, now numerous, are making many valuable contributions, especially to our knowledge of the mechanism of the special senses. But when I make a summary of what we now know of the physiology of the nervous system, I come to realize anew its paucity, compared with what we ought to know and will know, I am confident, in the long future. Here, it seems to me, is a field sadly needing tillage, and one where, though tillage be extremely difficult, the yield is certain to be rich.

All investigation here will lead up, in a sense, to the

solving of that problem of problems, which has been for ages the focus of discussion and speculation, the problem of consciousness—"at once the oldest problem of philosophy and one of the youngest problems of science." For centuries it has been thought about, talked about, written about, and with what result? The elaboration of hypothesis after hypothesis, which smell of the lamp—fabrications of the philosopher's cell rather than of the physiologist's laboratory. Almost without exception they are elaborate exercises in dialectics, rather than real portrayals of the nature of that most striking of physiological phenomena. To the physiologist they are almost without exception arid and unsatisfying. "Words, words, words," replies Hamlet to the question of Polonius. At first thought, the theories of dualism and interaction seem best adapted to the obvious facts of human experience: the brain and mind are two distinct entities usually intimately associated, and each capable of inducing phenomena in the other. But deeper brooding, and especially a recognition of the mode of action of the non-psychic portions of the nervous system and the close dependence of psychic on cerebral phenomena, of "how at the mercy of bodily happenings our spirit is," make us seek a more genuinely physiological explanation.

The physiologist recognizes as the morphological basis of nervous actions the neurone or nerve cell, consisting of a compact cell body, from which radiate outward filaments, the nerve fibers. He finds in the nervous system of the higher animal or man millions of such neurones and many more millions of nerve fibers. These constitute seemingly a confused and inextricable mass, but by careful study he has been able to discover an exact and definite, though excessively intricate, nervous architecture. He finds that the bodies of neurones act as central stations, to which and from which flow the nervous impulses along

the nerve fibers: the incoming impulses constituting the centripetal, or afferent, or sometimes sensory, impulses; the outgoing constituting the centrifugal, or efferent, or sometimes motor impulses. He recognizes as the physiological basis of nervous action, the reflex action, consisting of an afferent impulse, a central process, and an efferent impulse. He sees reflex acts combined in innumerable ways, and augmented and depressed by other reflex acts. He sees many of the most complicated actions of the individual performed with the aid of this reflex mechanism and without the aid of consciousness. He recognizes that a large proportion, if not the majority, of the individual's actions are reflex and unconscious actions. Lastly, he finds in reflex mechanisms no mysterious principle, but an ensemble of the same physico-chemical phenomena, which in one form or another he finds in other than nervous tissues, and in which the principle of the conservation of energy holds good. Turning now to conscious actions, he sees how indispensable to them, at least in the higher animal species and man, is a certain part of the cerebrum, especially the outer layer or cortex; and how the degree of intellectual development varies with the extent and complexity of this material structure. He sees how injury or disease of this part, or anything interfering with its proper activity, changes the individual from a sentient being into a non-thinking reflex machine. He sees acts, once consciously performed, now relegated to the unconscious reflex sphere. He sees how consciousness disappears in sleep, and how its manifestations vary under the influence of drugs. The cerebral cortex is composed of numberless neurones and is connected by afferent and efferent paths with the other portions of the nervous system. With these facts in mind, and though recognizing the intricacies of mental phenomena, the physiologist gets into the way of thinking that after all the mechanism of cortical actions

is really the same as that of other nervous phenomena. He sees no objective, *a priori* reason why an entirely new causative principle should be introduced to explain the action of this small fraction of the nervous system. Whatever its nature, consciousness appears to him, not as a distinct entity grafted on to certain nerve structures, but as merely one of the modes of manifestation of the activity of those structures, just as chemical, thermal, and electrical phenomena are other modes. Being thus one of the signs of nervous activity, the physiologist finds it difficult to see how consciousness can act as a cause of nervous activity, any more than can the heat given off in such activity react to produce itself. The physiologist sees that nervous systems, with all their functions, have undergone an evolution; he recognizes orders of consciousness,—a low, simple, gradual beginning, he knows not where, a progressive increase in complexity as nervous systems complicate, and the final culmination in self-conscious man. The relations of consciousness in its simplest form to the nervous system seem to be the same in kind as in the human being. For the physiologist, looking at the matter in this light, Huxley has probably formulated the best working hypothesis in his famous essay, "On the hypothesis that animals are automata." After a lucid analysis of the actions of animals lower than man, he says: "The consciousness of brutes would appear to be related to the mechanism of their body simply as a collateral product of its working, and to be as completely without any power of modifying that working as the steam whistle which accompanies the work of a locomotive engine is without influence upon its machinery. Their volition, if they have any, is an emotion indicative of physical changes, not a cause of such changes." And later: "It is quite true that, to the best of my judgment, the argumentation which applies to brutes holds equally good of men; and therefore

that all states of consciousness in us, as in them, are immediately caused by molecular changes of the brain substance. It seems to me that in men, as in brutes, there is no proof that any state of consciousness is the cause of change in the motion of the matter of the organism. If these positions are well based, it follows that our mental conditions are simply the symbols in consciousness of the changes which take place automatically in the organism; and that, to take an extreme illustration, the feeling we call volition is not the cause of a voluntary act, but the symbol of that state of the brain which is the immediate cause of that act. We are conscious automata." Objection after objection has been raised to the automaton hypothesis. It has been dialectically disproved many times. Its upholders have been charged with all the sins against logic, common sense, lucubration, spirituality and orthodoxy. And yet it will not down, for of all hypotheses it seems to accord most closely with the facts of neural physiology, as we know them to-day. It may perhaps prove to be not a finality; but whether in the distant future it be found correct or incorrect, it is from its general standpoint, it seems to me, that the physiologist of the present epoch can do his most helpful experimental work. The problem of consciousness should be taken into the physiological laboratory, and the conditions of the manifestation of psychic phenomena should be investigated by laboratory methods. All mental processes, even to the last degree, are dependent on and have their basis in brain processes. The physiologist should study in minute detail the cerebral process of each mental act. He can thus inform the psychologist as to the conditions under which psychic phenomena occur. "An individual fact is said to be explained," says John Stuart Mill, "by pointing out its cause." And again, "The cause of a phenomenon is the assemblage of its conditions." In this sense the explana-

tion of consciousness, it would appear, ought to come, sooner or later, from the physiologists.

I have spoken of the physiological aspect of other sciences. Pathology, the science of disease, or, in other words, perturbed function, is peculiarly close to physiology, for there is no sharp line of demarcation between the normal and the abnormal. We may assume the successive chemical substances involved in a certain progressive physiological act to be represented by the series A, B, C, D, in which A is the substance from which the chain proceeds. By analytic and synthetic processes A gives rise to B, B to C, and C to D, which is the final end-product of the metabolism. Even with the same quantity of A and the same strength of stimulus, the quantities of B, C, and D produced in successive repetitions of the act may vary considerably, owing to unknown factors. It is only when the intermediate or final products become markedly increased or diminished in quantity in comparison with their usual amounts, that we speak of the function as pathological. The excitability of cells may be greatly augmented or diminished and still be within the limits of the normal. A tissue may grow excessively, as in tumors, or may waste away, and yet normal function be not seriously interfered with until remote limits are passed. Bacteria may live physiologically within an animal body. They produce and cast off toxins, which intrinsically are poisonous to the cells of their host. These, however, cause a physiological production of antitoxins in the body cells. So long as the antitoxins are sufficient in quantity and strength, they neutralize the poisonous toxins. If the latter get the upper hand they augment or depress the physiological activities of the cells of the host, and we speak of the result as a perturbation of function. The power of the organism to adapt itself to changed conditions and to maintain its physiological status is little short

of marvelous. When, in spite of all endeavors, the physiological status is overwhelmed, then is the time for the pathologist to investigate and the physician or the surgeon to attempt to cure.

As in the biological sciences, so in the medical art, there exists a distinction between the morphologist and the physiologist, between the surgeon and the physician. The surgeon is the medical morphologist. His task is to remove diseased or injured tissue, to reunite separated structures, to restore structure or stimulate to its restoration, in short, to make structure normal, so that normal function may follow. The physician, on the other hand, is the medical physiologist. It is his endeavor to restore normal function. His life-long labor is an exercise in physiology. He should know his physiology as the surgeon should know his anatomy, minutely and to the last degree. He should know what health is before he tries to restore it. We all realize how rarely this ideal is reached, and we all have experienced the dire results of medical empiricism. Huxley likens nature and disease to two men fighting, the doctor to a blind man with a club who jumps into the mêlée, and strikes out right and left, sometimes hitting disease and sometimes hitting nature. Would not his blows be more telling if he were quite sure which of the combatants was nature and which disease? Wherein he fails to avail himself of present knowledge he is culpable. And yet he is not to be charged with the whole burden of his failure to cure. Some of this should be shared, I regret to confess, by the physiologists, for they still know too little of the normal action of the vital mechanism. So far is this true, that I am convinced that one of the surest and quickest means of inaugurating a rational and effective art of medicine is through the advancement of physiological discovery. All physicians must be in part empirics until the physiological millennium is ushered in.

If I have been understood aright, my hearers will have perceived that with a mighty subject matter which is pre-eminently its own, physiology extends a leavening influence into a host of other sciences and medicine as well. It is an unusually good example of the typical pure science, with its outlying affiliations and applications. Like many another natural science, its rise, growth, and early nurture were under the protecting wing of medicine. The physiologists of the early years, when their science was crystalizing out of the common mass of scientific knowledge, the men who first formulated its principles, and they who in later years developed it, were, with few exceptions, men of medical training who were under the influence of medical traditions and were guided by the medical spirit. In recent years the ties of the old traditions have been loosened, and the science is passing out from the parental shelter into the illimitable atmosphere of scientific freedom. Its aspirations in research are unhampered. Its achievements in research, in so far as it constitutes an academic theme, are limited by the fact that, except in a few isolated cases, physiology is still regarded by the university as primarily a medical science and its laboratories are housed in medical schools. This is a relic of early history. In consequence physiology must constantly breathe the medical atmosphere and must be influenced, whether it will or no, by medical ideals. This is not to be deprecated from the standpoint of physiological medicine, and the reciprocal advantage to physiology itself in this one aspect is also great. But this now anomalous state of affairs leads directly to two consequences: namely, first, that the broader biological aspects of the science are less dwelt upon than otherwise would be possible; and secondly, that where such aspects have been investigated the work has been done largely by men not professed physiologists and usually lacking the latter's exact training as

experimentalists. The customary academic position of the science thus imposes a certain restraint upon physiological progress, and delays its full fruition.

It is idle to try to predict the ultimate fate of the science that is attempting to make clear the vital process. To some minds it is attractive to speculate, and even to dogmatize, concerning the limits of natural knowledge. The present task of the physiologist is to investigate, and continue to investigate, ceaselessly and fearlessly, with a spirit ever fresh and hopeful, seeking only the elusive truth, unmindful of the limits of natural knowledge and undeterred by the fear that the mystery of life will ever remain a mystery. He must be content to spend his energies in patient laboratory research, accumulating facts, unifying facts, and deducing laws for limited spheres of vital activity, and thus to lay the foundations for the broader generalizations that will come after his labor has ceased. By his constant association with the material substratum of the life process and the continual discovery of new and undreamed-of possibilities in its action, he gains a respect and even reverence for living matter which only he can possess. None but he can realize and understand its supreme beauty and harmony and sublimity. He cannot sympathize with, much less share, the feeling that the material is base and only the spirit is uplifting, for to him the material makes its uplifting nobility manifest. He likes to believe, and to act on the belief, that no physiological problem is forever insoluble, and though ignorance may be long-lived, he sees no necessary reason for an ultimate, eternal *ignorabimus*.

BOTANY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
DECEMBER 4, 1907**



BOTANY

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COLUMBIA UNIVERSITY**

New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published February, 1908.

BOTANY

WHAT is the content and scope of the science of botany? Popular opinion will answer somewhat easily: Botany consists in the gathering of plants, and the dismembering of them, in connection with the use of a complicated terminology. That is the beginning and end of botany as it is understood by the majority; there is nothing more to be said. In consequence, the employment of the botanist seems so trivial, so very remote from important human interests that no second thought is given to it. The conception formed in ignorance is continued in ignorance. Even the zoologist is at an advantage, for the public is finally forced to admit that it does not know what he is about, while it understands the botanist very well. He is quite hopeless, for, while flowers may be pretty things to pick, they should not be pulled to pieces, and if he does not happen to be interested in dissecting flowers he is not a botanist but simply a fraud.

Far from being remote, the study of plants comes very close to human interests. One has but to stop to think that plants are the great energy source for man himself and the animals upon which his well-being depends, to recognize that a careful study of their manner of life, the conditions which favor or hinder their growth is of the very first importance. Besides this, human curiosity demands that plants be investigated, if for no other reason than that they must be made to yield answers to the per-

petual questions that man is asking regarding the world about him.

Under botany we have to consider all the questions as to the form, the functions, the classification and the distribution of those organisms that are called plants. Along what lines this study is prosecuted, how it is related to other fields of intellectual activity, and some specific instances of its problems and the manner in which they may be solved is what I shall attempt to tell you.

It would be out of place in a talk like this to devote too much time to a consideration of the historical side of the subject, and therefore only a few of the important movements can be pointed out. Any folk which had so far emerged from the stage of savagery as to stop to notice the world about it would perforce pay some attention to plants. A discrimination of the medicinal uses of plants is often noticeable even in primitive peoples, and with such observation goes also the discrimination of difference in form, the prototype of morphological research. I have seen a Malay coolie who could distinguish seven forms of tropical oaks where the botanist recognizes only four, an evidence that sharp observation is not confined to the highly developed races.

In our own civilization, we can trace back the history of botany to Aristotle, who affords us some record of the plant forms known at his time, though the influence which his philosophy wielded, even down to the middle of the last century, was of vastly greater importance than any contribution which he made to botany itself. Theophrastus gave a fuller account of plants, and later came the inquiring and ever curious Pliny. Dioscorides, however, in the first or second century of our era, was one of the first to investigate plants with any attempt at thoroughness even from the standpoint of the knowledge of the time. As is shown especially by Dioscorides' work, the study of

plants was largely from their use as drugs, and they were described simply to facilitate their recognition. Any real knowledge of them was naturally meager, and false ideas that clung for a long time, some until comparatively recently, prevented any proper conception of form and function.

As would be expected the contributions become of less and less value as we approach the middle ages, the botanical writings of which time were full of the wildest fantasy and superstition. The efforts of this period need not arrest our attention.

In the sixteenth century in northern Europe, particularly Germany, there was a movement towards the real study of plants from the plants themselves as evidenced by the works of the herbalists, but no attempt at classification was made. Here there was an attempt at the enumeration and illustration of plants from living specimens, and confused and empirical as this work was, it was actuated by an honest endeavor to record, as accurately as possible, actual forms, and not fanciful abstractions which never did and never could have existed. All the descriptions were detached from one another and little or no attempt was made at classification, though by the repeated study of many similar forms the idea of natural relationship began to dawn in a vague way. The actual purpose of all this plant study was the recording of the officinal plants, for special knowledge of plants was still confined to their uses in medicine.

While this movement was advancing in northern Europe, a mainly artificial system of classification was developing in Italy and found its culmination in the work of Caesalpino, who strongly influenced the progress of botany, even after his own time and into the middle of the eighteenth century. Great as was the advance he made, it would have been far greater had it been given him to

break away from the scholastic philosophy which hampered him. We find a curious mixture of a modern spirit of inductive natural science and Aristotelian methods of thought. The latter triumphed in the main, and the result was a formal classification built on idealistic abstractions that is wholly fallacious from our standpoint of to-day.

Emerging from such conditions we find Linnaeus—the bicentenary of whose birth was celebrated last year—and though he too was much influenced by the earlier writers, to him belongs the credit of the emphasis on the fact that some natural system of the classification of plants must exist even though he could not determine it. Linnaeus is popularly termed the father of botany and of zoology as well, and in many senses there is reason for it. He was a born classifier and brought considerable order out of immense chaos, but still his classification was artificial, and only to a very limited degree recognized the natural relationships of plant forms. Linnaeus, however, was wise enough to recognize its artificiality.

From Linnaeus the advance was more rapid, and, while most of the study in plants centered on the work of classification, there were unmistakable signs of other interests. The ideas of the classifier were still hampered by the dogma of the constancy of species, which continually clashed with the insistent and undeniable evidences of the genetic relationships of organic forms. Despite the movement in favor of the idea of the development of species from previously existing forms, despite the views advanced by Lamarck and others at about that time, despite, indeed, the more strictly botanical investigations in the morphological field which were brought forward during the first half of the nineteenth century: despite all these things, the botanist was unable to break away from the concept of groups of plants as abstract ideas. It was not until 1859 that the publication of Darwin's "Origin of Species" drove

biologists to a different point of view. Then the rational idea of the evolution of organic forms explained in a similar rational fashion the observed genetic relationships of groups of plants. No longer did the classifier hesitatingly admit the possibility of the evolution of species and deny that of genera and higher groups, no longer did he maintain his artificial groups, which had no more relation to each other than successive throws of dice, but he admitted the whole great scheme implied by the evolution of organic forms from pre-existing types.

Naturally, it is difficult to point out at just what time the modern trend of botanical work found its origin, but one can say, in a general way, that it was about the middle of the nineteenth century, although of the two criteria of progress to which I shall refer, one dates about a decade before, the other about a decade after that time. The establishment by the botanist Schleiden in 1838, and by the zoologist Schwann in 1839, of the real nature of the cell, and the acceptance of what may be termed the cell doctrine, at once made possible the development of the study of form and structure, both as to adult and as to embryonic organs. With improved optical apparatus and with improved technical methods, many able students added a vast number of demonstrated facts to the general store of knowledge; in fact, for a time the additions to morphological information very much outran the development of the physiological side, though the latter had had a rational beginning at a prior date. The morphological development depended in the first instance upon the understanding that the cell with its living protoplast, and usually with a wall, constituted a not further divisible morphological unit of living organisms; that every cell must have arisen from a pre-existing one; and finally, that all but the lower organisms are composed of thousands of these cells differentiated into distinct tissues. One

of the most important figures in this advance of botany from Schleiden's time was Naegeli, who brought to bear a powerful intellect on many of the fundamental concepts both of morphology and physiology. Of the many questions dealt with by him, that of the ultimate structure of organized substance was perhaps the most far-reaching; and today, despite its limitations, his Micellar Hypothesis, is the most stimulating of any of the theories which have been developed regarding this subject.

The other milestone of progress was Darwin's "Origin of Species" already referred to. Entirely aside from the particular question involved in that work, its importance lies in the fact that it fought the battle and won the victory for the inductive method of reasoning as applied to biological science. Previous to the awakening of botany, due to these and related causes, a botanist usually covered the whole field of his science and had the right to consider himself a specialist in all branches of botany. The rapid accumulation of facts soon demanded, however, a segregation of different lines of work. Thus arose the divisions of botanical activity, which, for our purposes, may be classed under three heads. First, the taxonomic, or as more commonly called the systematic side, which has to do with the classification, mainly as established by gross morphology. Second, the morphological field which concerns itself with the outward and inward form and structure and the development thereof, which may or may not have direct relation with taxonomic work. Third, there is the domain of physiology which treats of function. As Professor Wilson has pointed out, there are really but two divisions of biological work, the morphological and the physiological, so that the separation of taxonomy which really belongs in the first division is rather artificial. The separation however is necessary for many reasons, among which are the fact that the temper of mind and the

methods of the workers in the two divisions are quite different.

It is perhaps the tendency of the time, at least in many quarters, to underestimate the value of taxonomic research and this is to be regretted since in classification we have the foundations of other branches of work. Entirely aside from the philosophical value of a well ordered classification, it is an absolute necessity for a starting point of morphology and physiology to have the different species of plants recorded in recognizable form, and, in consequence, to have a classification. It would undoubtedly be a great advantage could organisms be classified as are chemical compounds or could be located as the astronomers locate the stars and in the same definite and precise manner. Such is hardly possible when we reflect that the question of the identity of an organism must, even under favorable conditions, be somewhat a matter of opinion as well as of demonstrated fact. Despite such limitations of taxonomy, in most of the really important questions opinion is fairly universal, so that our classification is not developed simply at the whim of any one investigator. Taxonomy, however, as soon as it is considered an end in itself sinks at once to the level of mere cataloguing or, worse still, loses itself in the mazes of nomenclatorial controversy. It must be considered in its relation to the problems of plant distribution, of the evolution of new forms, of its philosophical intent, if it is to retain its vitality.

I have spoken of artificial classifications in connection with the work of earlier botanists. How then does the natural classification as understood today differ? Primarily, it differs in the admission of genetic relationship of forms, a thing not conceived of by older writers. A natural classification implies higher and lower forms, connected by intermediate ones in all stages of differentiation. However, it does not imply that all these forms exist

today, nor does it imply that they developed in a single continuous series from the lowest to the highest. We have no particular right to suppose that all plants can be traced back to a single ancestor, indeed the evidence is against it. There is no reason why several phyla, or lines of ascent, may not have originated, perhaps simultaneously, from the most primitive form of living protoplasm. The story of the lower aquatic forms certainly indicates this possibility. Of these lower phyla some stopped short, some went on, which ones is a matter to be definitely settled. A good instance, though a somewhat special one, to illustrate the fallacy of the assumption of a single line of relationship, is found among the fungi, the chlorophyllless lower forms. Many ingenious authors have attempted to unite them in a single continuous series, when every evidence we now have points to their having originated at several places from the green plants. Who, indeed, would care to deny that new phyla might be originating today? Any concept of evolution demands such a possibility; organisms are more plastic than the average person conceives, even in this age.

The object of a natural classification is to consider all the many plant forms, to determine by such marks of genetic relationship as we can discover their place in the series, where they have departed from the main stem and in how far they may have had a line of development of their own. Despite what I have said about the lower phyla, it is not improbable that the higher plants can be traced back to some single source, not that it is to be believed for a moment that this ancestor exists today. Living ferns or mosses are no more to be considered the direct ancestors of the flowering plants than are monkeys to be considered the direct ancestors of man.

The establishment of our classification today might be compared to the putting together of a puzzle map some

parts of which are lost; we can determine how many of the parts fit together, and, by analogy, can tell something of the missing ones. The whole method depends on the admission of genetic relationship, a concept that is built up partly by the study of adult structure, partly by the story of the developmental stages, partly, though in botany less than in zoology, by the evidence of paleontology, but more vividly than in any other way by the actual behavior of certain plants in the matter of giving rise to new forms. This last consideration is of such great importance that we shall come back to it later.

One type of morphological investigation has to do with the study of life histories of plants,—the whole life story from egg to egg again—and here we find the morphologist in close relation with the systematist, for upon the results of such researches must largely depend the understanding of the relationships of the great groups. The morphologist who devotes his time to the study of life histories is engaged in the work of tracing the race history of plants from the comparison of the individual development of more or less nearly related forms. Thus the homologies which have been traced among the flowering plants and their nearest allies among the ferns and other forms indicate to us the probable race history of these groups. It is true that the beginning of this work dates back some decades, but it is still, to a large extent, an open field, and numerous investigators are actively prosecuting research along these lines. For example, the alternation of a sexual and nonsexual generation of plants which has long been known as characteristic of the life histories of higher forms has recently been established among the lower groups, and thus a much clearer view of the whole series of the plant kingdom is being obtained.

Somewhat separated, and to a large extent needlessly so, is the work of the plant anatomist and histologist.

Formerly pursued from the standpoint of the mere topographical relation of the parts, the conception of the plant as an organism with interrelated and interdependent tissues began to fall into abeyance, until a new point of view has within recent times revived a somewhat barren field. This point of view is the physiological one, the correlation of structure and function. Here the student of gross morphology and the anatomist unite in a physiological interpretation of the form and structure of plant organs, from which has grown the study of experimental morphology. Advance in this direction has been considerable, and we have now a much clearer idea of the nature and development of plant organs; or at least, we have a much better attitude in the interpretation of the facts that have been established regarding these matters. The danger which lies in this attitude is the well known one of teleological reasoning, and consequently it behooves us to have some caution in accepting, without thorough evidence, the interpretations which may be made of the relation of form and function and of special adaptations for special purposes. As some one has written, "so many things may be true and so few things really are in the matter of use of special organs," that we must demand above all things experimental evidence before we can accept as conclusively proved any statement as to function. It is permissible to say without such proof that such and such an explanation is plausible, but beyond that is uncertain ground and mere assertion shows a temerity at once magnificent and pitiable. On the other hand, it is questionable if the extreme attitude of iconoclasm as to long established interpretations is necessarily a wholly reasonable one. Destructive criticism is not difficult, and unless some new and better interpretation is suggested the advance in a scientific sense is not considerable.

A further development from this physiological attitude

is a branch of biological work known as ecology, a study of the relation and adaptation of single plants or whole communities of plants to their environment and to each other. It is the application in a broad and more philosophical way of the methods of the physiological anatomist coupled with those of the taxonomist; but, in addition, the work of the botanist touches the field of the physiographer and geologist. Ecology is the endeavor to uncover the plan of nature as it governs the relations of the different plant forms in a given area, to understand the why and the wherefore of the association of very different forms in one locality. The keynote of the philosophical development of this topic rests on the conception of the constant struggle of individuals or groups of individuals to maintain themselves against other forms, which leads to a balanced relation of the different species in a given flora. Understanding this, we can see why if this balance is disturbed the whole fabric of a plant community may be destroyed and a flora swept away. We are also able to understand how relatively slight climatic changes may alter completely the character of a vegetation in a given region, and thus to comprehend more readily the changes which must have taken place in past ages. It also shows us the effect of present changes, particularly in regard to the destruction by man of the essential elements of natural plant communities, notably one of the most important of these, the forests. Its use lies in these directions and the danger of its misuse lies in the direction of drawing too positive conclusions from data which are insufficient, and of accepting the results obtained as necessarily final, a common error it is true in any line of thought, but one to which the ecologist has especial temptation.

It is in the field of physiology more than anywhere else, perhaps, that the worker must humble himself before

the immensity of the problems before him; that he must realize how fragmentary is the most advanced knowledge of this subject. The foundation stone of physiology is chemistry, and consequently its advance must go hand in hand with the advance of that science; but there is also, it must be admitted, the element of empiricism, which is an unfortunate necessity in any branch of learning where any considerable mass of facts are not yet correlated. The greatest advances are made in the direction of resolving this empirical information into more compact and definite form, a task only possible by the accumulation and correlation of great masses of data in connection with the more definite information afforded by chemistry or physics and more particularly modern physical chemistry. It is plain, then, that we can never go ahead of the data afforded by these sciences, but must always follow somewhat behind them. It must not be supposed, however, that physiology is in a nebulous condition, despite the fact that we are but on the margin of the unknown. Distinct and creditable advances have been made since the days when the knowledge of plant morphology and the chemistry of Lavoisier made possible any reasonably satisfactory explanation of the functions of plant organs. The establishment of a proper understanding of how the plant obtains its food has been a matter of the utmost importance, both from the development of theoretical physiology, and from the standpoint of practical use. We know not only the definite chemical elements which are essential for plant life, but we know also the quantity and form in which they are most favorable for plant growth. Having established this, it is possible to understand the rôle of plants in the general economy of the world, and how their manner of life, in a broad sense, supplements that of animals. There is also pretty definite information as to the physical phenomena connected with

the absorption of the raw food materials which the plant afterwards elaborates, information which is largely due to the classic researches of Pfeffer, whose work, it may be remarked, also afforded Van t' Hoff valuable data for his contributions to the establishment of the modern physical chemistry. Application of the laws of diffusion and of osmosis, as shown by Pfeffer, enables us to understand why a plant may absorb more of one mineral salt than of another, though both be presented to it in solutions of equal concentration; why it cannot absorb some substances at all, while on the other hand it cannot avoid absorbing certain substances, even though they be violent poison and kill the protoplasm of the absorbing cell at once. We understand also a good deal of the mechanism of the production from simple inorganic substances of the first organic food by the green plant, the first organic food of the whole organic world. While, as will be shown later, the precise details of this process are not fully understood, the general facts are a matter of almost common information, so well known that I hesitate to speak of it here, though to sum up the matter in a few words it may be said that this process of photosynthetic activity of green plants is carried on by the living cells in the presence of sunlight, through the agency of the green coloring matter—chlorophyll—which is present in the leaves, and that the chemical reaction involved results in the union of the carbon dioxide absorbed from the air, with water absorbed from the soil, to form the first simple carbohydrate that is to be detected in easily recognizable form as starch. The fact that this process takes place does not interfere with the operation of another one, namely the absorption of oxygen with the giving forth of carbon dioxide, that is concerned in the mechanism of respiration. Respiration as a means of releasing the stored energy in available form for the constructive work of the organism

is as necessary in plants as it is in animals. These four fundamental questions, namely, the inorganic substances required by plants, the manner of their absorption, the manufacture of the first organic food, and the nature of respiration are perhaps the most important physiological facts, in the field of nutrition at least, which have been definitely established, and from any point of view their importance is a far reaching one.

In the other great field of physiological research, the study of the mechanism of growth and change of form, much information, made possible by the proper understanding of the cellular character of all living organisms, has established many facts as to the relation of plants to the great physical forces which govern the conditions, the rate and the direction of their growth. This is the study of the dynamics of plants, of when and how the energy released by the nutritive functions is applied to the up-building of new tissue and the movement of plant organs. Besides the questions concerned in the influence of diffusely exerted external factors, there are also the effects produced by these same forces when the stimulus is unequal or one-sided. The latter conditions result in characteristic growth curvatures or tropisms, which continue until the plant organ by its own action is brought once more into a state of equilibrium with the external forces. In short, the various plant organs are attuned to the normal conditions of equilibrium under which they grow, and have the ability to perceive and, to a limited extent, to transmit the impulses resulting from a disturbance of that equilibrium. This brings us to the question of the sense perception of plants, manifested in a somewhat bizarre fashion in the sensitive plant, but we should go very slowly in the direction of interpreting this perception in the same terms that we do that of higher animals. It is not for an instant to be supposed that plants have any nervous system such as

is characteristic of the higher animal forms. While plants can and do respond to differences in light intensity less than that which the human eye can perceive, it is gratuitous to suppose that there is anything analogous in the two processes. The possibility of any reasoning action or instinct on the part of plants is a question that the plant physiologist does not seriously entertain.

In selecting for discussion present day problems which may be considered fundamental, one is embarrassed by the wealth of material and therefore but one more or less connected series of topics which leads up to the modern mechanistic conception of life processes has been chosen. In doing so it has been necessary to ignore equally important questions which, though developed from no less a mechanistic standpoint, are more scattered.

In referring to the assimilation of carbon dioxide by green plants and the production of organic food thereby, it was necessary to admit that the details of the process are not satisfactorily known. It is evident, however, that the starch, which is the first substance that we readily recognize, is not the first substance which is formed. Modern research points more and more to the conclusion that it is the simplest of carbohydrates that is produced,—a substance known as formaldehyde. But what is especially interesting is that it seems not impossible that this primal reaction may not after all be a function of the living protoplasm, but a chemical reaction that can be carried on outside the cell through the agency of chlorophyll. It is in the further elaboration of this first substance formed that the living protoplasm is apparently necessary. At any rate we know that the energy demanded for the process must be afforded by the particular rays of sunlight which the chlorophyll absorbs.

In this photosynthetic activity of the green plant the carbohydrate supply of the world has been accounted for, but

there is an equally important question not concerned in this process, namely the source for nitrogen. Nitrogen is of course an essential element for the construction of protoplasm. As is well known most plants can utilize it in simple combination with oxygen in the form of a nitrate, a sharp contrast, by the way, to the typical animal which requires it offered as an organic compound. It is also known that the same plants cannot assimilate the free nitrogen of the atmosphere, and further, in the processes of decay, free nitrogen is liberated by the breaking down of the nitrogen compounds in dead organic matter. The logical conclusion of these momentous facts is that soon all the world's supply of combined nitrogen would be exhausted,—neglecting the relatively small replenishment induced by cosmic forces—so that green plants and consequently animals, would not have the wherewithal to live, unless there were some organisms which could avail themselves directly of this inert gas. Now there are plant organisms which have the ability to assimilate the uncombined nitrogen of the air, certain bacterial forms, and it also appears some somewhat higher plants. But the operations that lead to this result are by no means satisfactorily explained, and the whole topic is one of live interest both from a theoretical as well as a practical standpoint. It should be added that from the latter point of view, a process by which a combination of nitrogen with other elements in a form that is acceptable to green plants has been devised, and bids fair to become of great importance, for combined nitrogen is the great need of the organic world.

The processes of nitrification naturally lead us to the question of the elaboration of nitrogen compounds within the cell, of the final construction of proteid material that is the actual food of the protoplasm; but here we are much in the dark, partly because we have so little real

information as to the chemical structure of the more complicated nitrogenous substances. The explanations now given as to how this elaboration takes place are largely hypothetical and must be regarded as quite unsatisfactory.

A step further from the proteid food is the question of living protoplasm itself, and one of the most interesting problems connected with this is the nature and functions of the enzymes,—the ferments and digestive secretions of living cells. Many of the newer theories as to the nature of living protoplasm hark back to investigations regarding enzymes, indeed some extremists advance the opinion that the activities of the live protoplast are in themselves but the result of the interaction of substances enzymatic in their nature. There is no doubt of the power of the appropriate enzymes when present even in infinitesimal amount to cause enormous molecular changes in the substances on which they act, but it is necessary to exercise extreme caution before accepting generalizations along this line, no matter how brilliant. The amount of empirical information in this field is already becoming unwieldy, and nowhere else is the necessity of unifying principles so plainly shown. Here it is that more definite chemical knowledge may in one stroke clear up the whole situation.

If it is not possible to ascertain the chemical structure of a single enzyme, how much more difficult then must it be to determine that of the living protoplasm? It goes without saying, that if we try to analyze the living protoplasm, in the ordinary chemical sense, we kill it. This being the case, the student who is trying to penetrate these difficult problems must have recourse to other modes of attack. Therefore does he experiment with the effect of agents which do not kill but merely stimulate the organism or partially inhibit its functions and, by studying the nature and products of the reactions produced, obtain

in an indirect manner clues to the real nature of life processes. The fascination of these plunges into the unknown is perhaps hardly comprehensible to those who are not engaged in the work, but all must admit the importance of the end they have in view, namely to penetrate a little further into the mystery of life. The advance in all these fields is of necessity along the line of the mechanistic conception of vital manifestations, that is, the reference of them to chemical and physical laws. To appeal to a "Vital Force," as my predecessors in these lectures have said, is to appeal to an empty name, a mere "question-begging epithet." It is obvious that if we are to make any progress at all, we must admit of the possibility of some solution that our senses can perceive, even though we are perfectly willing to admit that the final answer may never be reached. The reference of vital phenomena to a vague "Vital Force" would mean the extinction of inquiry by robbing the investigator of any sense of responsibility for adequate explanations of the results of his researches.

As you have heard in previous lectures, there is an increasing tendency on the part of biologists to segregate less sharply the physiological and morphological fields of work, to take a broader view of not only the content but also the methods of the two branches of biological investigation. It must not be supposed, however, that in this tendency towards co-operation there is a return to omniscience of the type of the old-time naturalist, who by reason of the lack of detail was able to consider himself proficient in many branches of science. The modern morphologist must still be a morphologist, and the physiologist a physiologist, only he has a broader point of view and does not hesitate to avail himself of the cognate branches of his science, or of any other science where he feels that he can further the aims of his researches; he is

an eclectic and picks that which will serve to advance his work along the most fruitful lines.

Almost any investigation of wide scope is in these days an example of this improved attitude, but no other perhaps illustrates so conclusively what may be called the highest type of modern research as does the development of the Mutation Theory first propounded by De Vries. What De Vries has really done is to bring within the range of experimental proof certain questions which heretofore have been regarded as matters of observation and speculation alone. From this point, which might be said to have had its origin in the acuteness of observation of the taxonomist and morphologist, the physiological trend has ever increased until the last word in this discussion may perhaps be for the physiologist alone. The great question involved in the Mutation Theory is the old, old problem of the origin of species, a very considerable advance in which has been made by De Vries and those who were stimulated by his work. It is quite wrong to suppose that he has controverted the general results of Darwin's work; he has supplemented it, brought it within the range of more conclusive proof.

As the Linnaean or collective species may be regarded today they are usually separable into several more or less distinct strains which show no intergrading forms, and the diagnosis of any one species is, so to say, the average impression of them. To these distinct strains De Vries has given the name elementary species, and according to his interpretation they are the really discrete, finally segregable units, between which no intermediate types exist and concerning the origin of which we are really concerned. It matters not whether it was through ignorance or simply from convenience that the earlier taxonomists grouped many of these forms into a single species; we must conclude, that in general species, as recognized by the books,

are quite artificial. It matters not, also, what we call these finally not further resolvable forms. Therefore let us accept De Vries' terminology and use the term elementary species; the real point of the inquiry is how did these forms arise. It is upon this that De Vries' work has thrown a great light. He has shown that they may arise suddenly and without previous preparation from pre-existing forms, in which case the elementary species may be termed mutants, and the theory which has to do with the investigation of their origin the Mutation Theory.

The next task then is to examine more closely the methods which De Vries employed, the evidence which he has to support his views, both as to the observations on the origin of these mutants and their behavior after they have come into being, and further, what success subsequent investigators have had in supporting De Vries' evidence, and how far they have extended his conclusions. In the first place, it may be remarked that the conclusions as first published in 1901 and 1902 were not the outcome of any hasty experiments and ill digested data, but were the result of seventeen years of the most careful and painstaking work, and a fine example of the best kind of quiet, faithful research, removed from the rush of affairs and the demand for immediate results, the final conclusion of which fully warranted the time and labor expended.

As is well known, Professor de Vries found in Lamarck's evening primrose—*Oenothera Lamarckiana*—a plant most favorable for observation, though his conclusions are not based on that form alone. The most carefully guarded pedigree cultures were made from the true *Lamarckiana* type, and the astonishing result developed that among the offspring of these certain forms, to the number of about four per cent, showed new and striking differences. In all, more than a dozen new forms were obtained which, if they could be bred at all, bred true to their

new characters and did not revert to the ancestral *Lamarckiana*; these were the mutants, the new elementary species, which had sprung suddenly in a saltatory fashion from the parent stock. The great importance lies in the fact that they were entirely constant to their new characters, and were thus not in the class of the merely unstable varieties. It must be remarked that time alone, many generations, of carefully guarded cultures in which accidental crossing was an impossibility, together with unimpeachable records, could adequately establish this momentous fact, that here was a new species, a new form, or whatever you may elect to call it, which had sprung all in one jump from its parental stock. De Vries, then, was the first man who ever saw a new type of organism come into the world and who recorded its advent.

You naturally ask how unlike were these new forms, a question which is difficult to answer without actual illustrations. However, it may be said that many of them were different enough from their parent stock to be admitted by taxonomists to come within the definition of new species, as species are regarded at the present time. The differences are not the question of mere stature, but of the whole habit of the plant and of the details of the form of both leaves and flowers. But to repeat, it really makes no odds whether the differences are of such quality that they must needs be recognized as specific by taxonomists; what is important is that they are differences which do not intergrade one with another and which are inheritable in the second, third and subsequent generations, and that no tendency to revert to the parent form is to be observed.

The results of De Vries have been verified by cultures in this country of his own and of other stock, so that there can be no question that this Lamarck's evening primrose behaves in its manner of mutation the same here as else-

where. More than that, other mutating forms have been discovered, and by the application of biometric methods much that is important regarding the relative variability of mutants and their parent stock has been determined. Besides the actual experimental work, the history of Lamarck's evening primrose has been traced back for more than a century and a mass of inferential data is being accumulated which helps to support the main conclusions. Important as all these advances are, the most brilliant result is that obtained along the lines of the induction of mutations. By the injection into the developing ovary of a plant allied to Lamarck's evening primrose of reagents which might produce a chemical or osmotic effect upon the cell contents, MacDougal has actually succeeded in inducing mutations. The seed grown from the stimulated plant may produce forms quite distinct from the parent type and, what is essential, the mutations thus induced are constant to the second and third generations. That such a result can be obtained is simply astounding when one considers how firmly bound an organism is by its heredity. It would appear that a tremendous shock had been given the plant at a critical period in its life history which has enabled or forced it to break down some of the minor barriers imposed by its hereditary tendencies and to erect new ones, which circumscribe its offspring as the original ones did its parent. As to the precise nature of this shock we can at present only speculate, but it is permissible to suggest that it is perhaps of the nature of the rearrangement, in a chemical sense, of the protoplasm of the cells of the sexual generation. As to the natural production of mutants, given such a conception of the nature of the process involved, it is possible to suggest various ways in which it might have been brought about.

The line of departure of mutants from the parent type is not in any one direction, and the manner of variation

appears to be wholly a matter of what we are pleased to call chance. As has been said, De Vries obtained more than a dozen different forms. Some of the mutants, we may say, are probably destined to failure, others perhaps are better placed, at least in new environment, than the parental type and might conceivably stamp it out in time. What the criteria of success or non-success may be is a matter upon which no one would care to give an opinion, but I have in mind the fact that one of the mutants of Lamarck's evening primrose has a tendency to germinate somewhat more quickly than the parent form, and the seedling grows a little more rapidly; it is conceivable that some slight advantage of this sort might be the crucial point. However that may be, it is here that we can apply the Darwinian concept of the struggle for existence, a struggle however not between single individuals, as the idea of continuous variation would imply, but the struggle between great numbers of individuals, whole groups of elementary species. The great contrast between Darwin and De Vries is the contrast between the slow and continuous accretion of variations implied by the former and the sudden jumping or saltatory variation insisted on by the latter. By such means as De Vries maintains the process of evolution might take place with far greater rapidity than by Darwin's method, for, generous as the geologists are in their allowance of time for the development of organic life on the world, it has always been difficult of conception how even the countless ages granted could compass the enormous development of the highest organic types from simple forms. To maintain that De Vries' theory is entirely complete, and must be the only means of the origin of new forms, is unnecessary. None but the extremist would go to such a length; it is not at all necessary to assume that the means to a similar end must necessarily be similar.

What may be maintained, and properly so, is that mutation constitutes one way, at least, by which new forms of organisms may arise on the world's surface. New forms, in the sense of the new combinations of old characters which come into being by reason of stable, non-reverting hybrids, are known to have originated, but such new forms imply of course the pre-existence of varied types, and do not have to do with the question of the origin of new characters.

It is not in the order of things that a new theory of such import as the Mutation Theory should not find opponents. These I think may, in the main, be grouped in three classes. First, the critics who doubt the evidence, who can be answered by referring them to the printed records, and recommending a repetition, as careful as the original work, of the experiments which have led to the new point of view. Second, those who quibble concerning terms, and this type I think constitutes the majority, who will likely suffer the fate that is usually meted out to quibblers, that of being ignored. Lastly, those opponents who, while they may not doubt the accuracy of the work, doubt the conclusions on philosophical grounds. These are the critics whom the advocate of the De Vries Theory must welcome and who will arrest his sober attention, for they will stimulate him to accumulate more and more evidence to support his position. Even were I able to analyze adequately the controversial side of the question for you, it is obvious that time scarcely allows, and I will, in consequence, state frankly that the account which I have presented is from the standpoint of an advocate of what the Mutation Theory teaches, and add that I am not aware that any experimental work has controverted it. Let me say, however, and here I wish to speak for myself alone, that I cannot see it makes great odds whether fifty years hence or five years hence we accept the Mutation Theory

just as propounded by De Vries. The great point is that an advance has been made, the most important advance since the time of Darwin, by way of helping to elucidate one of the great questions in which man is interested. It is not to be supposed that we have as yet any final answer to this question, final answers are not indeed the goal of any one scientific research. It was Sir Isaac Newton, I think, who said that the seeker after ultimate causes did not show the true scientific spirit, and he was right. What we have is one of the proximate causes demonstrated to a degree which had not been previously attained. A scientific theory is like an organism, it grows and it may also propagate itself, and all the theories of evolution from Lamarck to De Vries, and those that will follow, will themselves be an example, as it were, of the principle that they teach. A theory starts life an intellectual pigmy, may develop, if it have the vitality, into a veritable intellectual colossus, and, after it has run its course, may leave behind its offspring. It is not a cause of reproach but rather of congratulation that the scientific theory of today may be discarded tomorrow, for no theory will be abandoned until a better one has been brought forward to take its place, one which can explain the facts in a way more satisfying to the human mind. Change in such a case is progress, and since science must of necessity be always progressing so also must it be always changing.

To those who are conversant with the problems connected with the origin of species it must be obvious that this consideration of the subject does not cover the whole ground; so obvious indeed that perhaps it is unnecessary for me to remark that it is not intended to. There are other theories to be considered and other equally important matters that are more or less interwoven with any one theory of the evolution of new forms. Thus no reference has been made to Mendel's researches on heredity, or

the way in which they touch upon the De Vries Theory. This has been omitted purposely, for while the results of Mendel's original experiments in the breeding of peas might be cited at length, I doubt if an apter or more significant example could be found than the one which Professor Wilson used, and as Professor Wilson himself said, the explanation while not abstruse is one that requires considerable preparatory consideration. The Mutation Theory has been developed more in detail, as representing a type of research. Being one of the latest and most important contributions to biological science, and being also entirely germane to the subject in hand, it has seemed proper to devote some time to its consideration. At many points do the fields of modern botany and modern zoology touch, but perhaps it is nowhere so evident as in great problems like these. Here the two sciences work in generous rivalry, each eager to add its contribution to the store of general knowledge, to utilize such information as the sister science brings, to criticize it if need be, but always to accord it a respectful hearing

So much then for the purely theoretical side of botanical research of which I have presented a hasty glimpse. It is necessary before closing to make some reference to the utilitarian aspect; where and how botany directly serves the material needs of man. I hold it myself to be a matter of some pride that a science like botany with a side so purely theoretical and impractical can also lend itself to further, in such important ways as it does, the well-being of mankind, for in the direct application of botanical information to agricultural questions the ways and means of life may be ameliorated. Moreover, it is some of the most theoretical and recondite researches which have led to the most important practical results.

It is possible to consider only a few phases of the practical application of botany, and I will choose those which

are not commonly recognized, and which require a high degree of special botanical training. The necessity of botanical knowledge in the use of plants and their products in the arts, or as drugs, is easily understood without further reference, and such uses do not necessarily involve any broad knowledge of plants as a whole.

It is quite different, however, in the matter of plant pathology, for here every channel of botanical information must be used to investigate plant ailments. Bacteria and parasitic fungi, which are themselves plants of a low order, are the cause of the bulk of plant diseases and for that reason the study of their life histories becomes a matter of no small importance. Then, too, the structure and habits of the host plants must be taken into consideration, for upon these may depend the means of prevention or of cure. The assembling of this information and its practical application to the question in hand devolve upon that type of botanist usually referred to as the mycologist, and despite many failures much that is of substantial practical use has been established. One of the earliest, if not the earliest, recorded instances of where a community has taken formal notice of the fungus pests of plants is found in the old Barberry Law passed by the province of Massachusetts before the Revolution. This called for the extirpation of the barberry which had been noticed by the colonists, without any knowledge on their part of the real cause, to be connected with the rust of their wheat fields. Today we may not pass laws for the destruction of diseased plants, realizing perhaps the hopelessness of enforcing them, but we combat plant disease by the establishment of experiment stations devoted to the investigation of such matters.

As a result, there is now at the disposal of the agriculturalist much definite information of ways and means of diminishing or preventing loss through the destruction of

crops by disease, losses which statistics show may amount to tens of millions annually; and while the study of the action of bacteria and fungi in the disease of plants is by no means complete, no one can deny the practical results which have been attained. In the more indefinite functional diseases of plants not ascribable to definite parasites, there is room for much more information, which will be forthcoming when our knowledge of nutrition physiology is more full. Already, however, we have suggestions as to the cause of the functional diseases which often appear where the same crop has been raised for many years in succession in the same spot, which bid fair to explain some important plant ailments that are at present not understood.

A more popularly interesting line of activity that has a practical bearing is found in plant breeding, which has recently been attracting wide attention. Plants are now bred systematically for desired characters, not always simply for increased yield, but also for such qualities as resistance to extremes of temperature, to lack of moisture in dry or semi-arid regions, to resistance towards specific diseases, and even for the more esthetic qualities of flavor or color. The old hit or miss methods of the improvement of strains by empirical rules of selection is passing away, and more and more scientific methods, based on the latest results of investigations of heredity and variation, are being employed. Passing over the older methods I will take up two very different types of plant breeding, both modern: one the strictly scientific, the other the intuitive.

The first method we owe largely to Nilsson, who introduced it at an experiment station in Sweden in connection with the cultivation of various cereal crops. It may be said that previous to his advent the older methods had been tried and abandoned as a failure. With his knowledge of what had been published about heredity and

variation, Nilsson, after some preliminary experiments, arrived at the conclusion that no new, pure or constant strains of wheat could be obtained unless the fruit of a single ear was bred separately, and thus he established what is known as the principle of breeding from the single ear and not from assorted lots of seed taken from many individuals. This breeding he continued, picking out any chance favorable ear which he could find, until he obtained many thousands of different forms owing to this multiplicity of strains mixed in the ordinary wheat. Of course some turned out to be mere bastard strains and only the ones which continued to breed true to character were kept. These constituted the new agricultural varieties,—in reality elementary species and mutants—which, after severe tests had proved them suitable, were raised in marketable quantity for seed. The amount of work involved was enormous, the mere bookkeeping of the accurate pedigree record with notes on the life history of each form and its progeny was in itself no small matter. Besides the principle of single-ear breeding, Nilsson also established the fact that but a single selection alone is necessary to fix a new strain, provided the progeny of the chosen ear are carefully guarded from admixture with other forms. All this seems absurdly simple, and it is simple, so much so that it is quite possible of application by a person of average intelligence who has had the proper instruction, but the important point is that it was discovered by the application of thoroughly scientific methods. Nilsson's principle is in very general application today and is being used to excellent effect in the improvement of Indian corn in the middle West.

Contrast with this the methods of Mr. Burbank, whose name is familiar to all. It is not that he should not be given the credit of having established new and useful strains of cultivated plants, or of having done some

remarkable feats in the way of plant breeding; but it is that his methods are almost purely intuitive and would die with him, were his own records all that there was to be left behind, a striking difference from the mass of data accumulated by Nilsson. It is the rule of thumb method, picturesque but uncertain, as against the surer but less romantic practices of science.

The matter of general scientific agriculture opens an immense field in which I can call your attention to a few points only. The scientific care of our forests, for trees may be regarded as a crop and their culture agriculture, is a question to which we in this country are awakening none too soon. Forestry as practised in Europe, demanding as it does expert botanical knowledge, perhaps not by the foresters themselves but by those who direct their labors, has saved what were the fast diminishing wooded areas. There is need of haste with us for similar scientific treatment of the problem by men who are not simply woodsmen, but botanists as well.

The scientific rotation of crops, the use of fertilizers and the study of the physical and chemical condition of the soil in connection with the living plants, involve questions which may mean the success or failure of much of our farming. These questions can only be settled by careful investigations which take into consideration the nature of the plants themselves as well as the physical conditions of their environment. Some may say that knowledge along this line has been satisfactorily handed down from father to son, that the farmer knows his business better than does the scientist, but it is a patent fact that this is not so. For instance, many a farm which has been damaged for a long period of years by the over-liming of the soil might have been spared had the farmer of fifty years ago had the knowledge, which we now have, of the relation of lime to the other mineral substances needed by the

plant, of when to apply it and when to withhold it. It is the difference between merely empirical knowledge and that which is based on scientific principles.

When the contest comes between virgin soil and long tilled land, the latter, no matter how rich it may once have been, must needs be cultivated more intensively if it is to hold its own. Intensive cultivation requires the aid of special information and it is here that scientific agriculture comes into play. Few people realize that, without artificial fertilizers, the direct outcome of highly theoretical work on the raw food stuffs of plants, much of the farming of today would be almost impossible. And the proper use of fertilizers is but one of many questions.

We are coming now in this country to a stage in its development when scientific agriculture must be seriously considered. Fortunately it is being so considered and the federal and state establishments devoted to the investigation of these agricultural questions may confidently be expected, I think, to help in the solving of the practical economic questions that must arise in the competition of our own agriculture with that of other lands. The way it must be done is by the introduction of improved methods based on carefully conducted scientific research, that often find their stimulus in the highly theoretical investigations of the pure scientist. Thus must the so-called impractical devotee of science come in contact with the practical man of affairs and furnish him knowledge that can be used for the benefit of all.

In this somewhat categorical fashion then, I have endeavored to present to you some of the content of the science of botany; that science which consists of the dismembering of flowers and the giving to them of long names. What its future will be is perhaps already indicated, but briefly you can see that it is the direction of physiological advance, away from pure taxonomy and

formal morphological conceptions towards the realm of function; away, too, from any segregation of the science from kindred fields towards a better understanding of the place of plants in the whole cosmic scheme.

Man's attitude towards the unknown,—his philosophy in short—must influence his attitude towards botany as it will towards any science; and since philosophy, like other lines of intellectual activity, changes and progresses, man's attitude towards science is not a fixed or rigid one. But it is not likely that philosophy will ever tend to discourage investigation, and investigation is the keynote of scientific progress. Unquestionably, the world demands research, and any fact no matter how humble, if accurately established, helps on the cause. Perhaps the time will come when our knowledge of today will seem as crude as that of yesterday now seems to us. Let not that concern us, except to urge us to do what we may in hastening this time, knowing that that is where real progress lies, and knowing too that there is ample work that can and must be done.

ZOOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
DECEMBER 11, 1907**



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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published February, 1908.

ZOOLOGY

IN the present series of addresses upon the nature and scope of some of the divisions of knowledge, zoology connects the natural sciences with those subjects that deal with human progress in physical, social, political and economic respects. Like the human and other sciences, zoology has arisen from that vague uncoördinated and unresolved mass of knowledge, the Natural Philosophy of not very remote times, which undertook to comprehend all there was of nature and thought. And again like the other sciences it is as such a branch of relatively late growth. In earlier times few men were sufficiently withdrawn from the affairs of the market-place and commerce and conquest, from politics and government and theological propaganda, to observe the phenomena of nature closely, to reflect upon their observations, and to summarize their deductions in the formularies of natural law. Not until human social structure neared the relatively settled condition of modern times did it become possible for men to differentiate as students of nature solely, rendering their service to the common weal as investigators of the less practical and more remote departments of knowledge. Now the sciences have become so great, so complex and varied, that it is impossible for a single mind to comprehend all that is included in one of them. So widely the impelling energy of research has driven the soldiers of investigation that only when, as in the present series of addresses, they return to the council-fires of an intellectual

bivouac can they come to realize how far-flung indeed are the battle-lines of the armies of science—how rich and diversified is the territory from which knowledge has driven ignorance and superstition. And they must realize also how impossible it is for them to conduct their operations at all times in entire independence. The results of physics and chemistry are indispensable weapons for the biologist; geology takes the field with paleontology for the study of fossil forms; while on the other hand the advance posts of zoology provide the students of many a human science with a secure base of operations.

I need not speak of the inter-relations of the several biological sciences, for these have been sufficiently explained in the earlier discourses. I shall pass directly to a description of the elements of the present science of zoology and of its history, so far as this is necessary for a clear understanding of the various divisions of the subject and of their connections; and finally I shall endeavor to show how through its human materials zoology articulates directly with other fields of knowledge.

ZOOLOGY is the science that deals with the structure, development and inter-relationships of animals, with the workings of their parts, their activities and their relations to their environment, and with the factors that determine their forms. We may recognize two great divisions of the subject, which are concerned respectively with static and with dynamic principles, though the materials of both divisions are the same—namely, all animals throughout the entire range from the highest to the lowest. It is of course clear that morphology—the science of structure—cannot be absolutely separated from physiology—the science of function in its widest sense—for we do not know of organic structures that play absolutely no part in an animal's

economy, even though this may be a relatively passive one; while on the other hand we do not know—in science at any rate—of a function that is devoid of a material basis. The division is made solely for the sake of analysis, and it depends entirely upon the point of view. Morphology treats adult animals, their different developmental stages, and, more naturally, the remains of extinct animals as though they were arrested in their living, but the dynamic aspects of organic life are so prominent and insistent that it is really impossible to ignore them even temporarily.

Besides dealing with the same materials, the many complicated problems of zoology are still further connected in that the central object of study for both the structural and physiological divisions is evolution. As we look back over the history of the subject from our modern vantage-ground, we can see how zoology began with ancient and mediaeval natural history, how from this parent stock arose the additional separate branches of anatomy, embryology, paleontology and distribution, how human physiology became comparative physiology which developed later into the broad and deep enquiry into all the activities of animals, their vital relations to one another, and their reactions to and upon the environment; and we can see how all these several branches were vitalized by the great principle of evolution. This whole history shows a steady progress through one phase after another toward the modern study of evolution, though the naturalists of the eighteenth and even of much of the nineteenth century were unconscious, in whole or in part, of the way their observations and views were contributing to the establishment of the doctrine of descent and to the partial description that can now be offered of the natural factors of evolution. As we shall see, the structural analysis of animals demonstrates the evolution of species as a universal process, while the broad study of the dynamic relations of

animals is concerned with the causes of this process, as what we may venture to call the physiology of evolution. In brief, then, the great questions of zoology are the *what* and the *how* of evolution.

In view of the earlier lectures, it is unnecessary to speak at length of classification or taxonomy—the first division of static or structural zoology. Aristotle, who gathered and studied some five hundred of the more common animals of the earth and shore and sea, and the mediaevalists Wotton and Ray, Gesner and Aldrovandi, were animated primarily by the instincts of the collector of interesting information. Linnaeus, the great figure of the eighteenth century, rendered an immortal service to zoology (and botany, too,) by introducing the present ordered system of naming and classifying organisms. But classification was to Linnaeus an end in itself, he could not see that it was but a means to the larger end of understanding and expressing evolutionary relationships,—that resemblance meant consanguinity. It remained for Erasmus Darwin, the elder St. Hilaire, Lamarck and others to appreciate this inner meaning which so vivifies the otherwise dead details of taxonomy.

The many connected details of animal structure and development and function constitute the threads, as it were, which are interwoven by comparative treatment to form the warp and woof of the fabric of zoology. Classification draws upon this fabric the pattern of genealogical connections, emphasizing those threads that run furthest, the so-called distinctive or diagnostic characters. And though the pattern must be altered here and there as knowledge increases, the zoologist feels that it has a real significance as a representation of evolutionary descent.

As more and more of the lower animals were brought by the microscope from the obscurity of their zoological underworld, as exploration revealed more of the creatures

of previously unknown lands, as investigation became more detailed and intensive, comparative anatomy arose as an independent branch of zoology with distinct purposes of its own; and it gained its specific form and character from the studies of the great zoologists of the early nineteenth century—Lamarck, Cuvier, Geoffroy St. Hilaire, Goethe, Owen, and Oken. These naturalists dissected and compared the various organic systems of animals, following them as widely as possible from group to group of the numerous vertebrate and invertebrate forms, and they and their followers have placed the doctrine of evolution upon the sure and broad foundation of comparative anatomy. The main principle of this department of zoology is that the varied forms of animals exhibit deep-seated likenesses that place them in groups related to one another not as the rungs of a ladder as Lamarck supposed, but rather as the branches of a tree or a bush; and such branches again like those of a tree bear smaller branches, and these reach to lesser or greater heights from the base level of primitive organization. Thus, anatomy holds that community of plan is an indication of genetic affinities, while modifications of a common plan exhibit the results of adaptation to different ends through evolution. The framework of the human arm is constructed out of the same elements with the same arrangement that we find in the leg of a cat, the flipper of a seal, the paddle of a whale, and even the wing of a bat, different though these structures are in function,—and in these resemblances comparative anatomy discerns evidence of a remote common ancestry of men and whales and bats.

Extended through the study of tissues, or histology, to the unitary elements of organic structure—the cells—comparative analysis has brought the whole realm of organic nature under the sway of a great principle—the cell-doctrine of the botanist Schleiden and the zoologist

Schwann. This important principle, propounded in 1838 and 1839, produced an immediate effect in unifying organic creatures, though many years passed before it was formulated in the terms employed to-day. In brief, it is this:—All the larger organisms are composed of organs which in turn are constructed of various tissues, like muscle and nerve and connective elements; the tissues finally can be resolved into units of structure, the cells, which agree in possessing a central body or nucleus, and in their protoplasmic substance. The elementary nature of cells is still further demonstrated by the simplest organisms we know, which consist of one cell, nothing more and nothing less; while finally the starting point in the development of higher animals is always a single cell—the egg. Truly these are remarkable facts, when we consider the wide range of animal and plant forms.

Vast as the present knowledge is, the tasks of comparative anatomy are not entirely completed. Though voyages of exploration like those of the *Beagle* with Darwin, the *Rattlesnake* with Huxley, and above all of the famous *Challenger* have gone to all parts of the globe, though countless investigators have devoted their lives to the study of special groups like birds and mammals and insects and molluscs, every year brings to light new forms that must be analyzed and placed; while new discoveries in other departments often make it necessary to re-examine known series in the light of fuller knowledge.

While many naturalists prior to the nineteenth century were interested in the way an animal egg produced an adult organism, it was not until the doctrine of descent energized zoology that comparative embryology attained the independent status that it holds to this day. Harvey in 1650 had perceived that, in his own words, “all animals are in some sort produced from eggs.” Bonnet and Haller, of the early eighteenth century, contended that the germ was

a minute replica of the adult which formed it, a *multum in parvo* which simply unfolded and enlarged to produce another adult organism; Wolff, however, showed that this view lacked a basis in fact, and that as we now universally believe, embryonic history is a true development from the simple and unorganized to the progressively more and more specialized later conditions,—that it is, in a word, an epigenesis. The great name of the infancy of embryology is that of Von Baer (1792–1876). This acute observer and thinker was struck by the similarity of early stages in the development of quite different adult animals. Birds and reptiles and even mammals pass through stages when they possess gill-slits like those of fishes, related to heart and blood-vessels like the similar structures in lower vertebrates; butterflies and flies and beetles are somewhat alike in their larval stages, when as caterpillars and maggots and grubs they not only resemble one another remarkably but they are also very like worms. Under the influence of the evolution doctrine, then becoming more generally accepted, Von Baer and a host of followers extended the science of comparative embryology until Haeckel in 1866 ventured to state the “Law of Recapitulation,” or the “Biogenetic Law,” in the following rigid terms:—Ontogeny recapitulates Phylogeny. (The development of an individual reviews the past history of its species.) Led by their enthusiasm many of the later nineteenth century zoologists followed too implicitly the lines of the embryonic record, though Haeckel himself, the most radical advocate of the law, pointed out that there are many serious omissions in the narrative, that false passages are inserted as the result of purely larval and embryonic needs and adaptations, while many alterations in the way of anachronisms have been made. Of late years there has been a strong reaction from the complete acceptance of the principle as a reliable mode of interpreting embryonic histories. But I believe

zoologists generally feel that used with due caution the law has a high value for the student of evolution, and they realize that embryology is perhaps more significant in other respects than in showing exactly how in past times any given species has evolved. The present tasks in this department, now so thoroughly investigated, are to distinguish between the false and the true portions of the record, between the new and the old, and to ascertain the physiology of development, in order to gain a more complete knowledge of racial history and of the dynamics of organic nature.

The study of the fossil remains of animal organisms, or paleontology, is the fourth division of structural zoology, which as an independent branch dates back to the time of Cuvier, scarcely a hundred years ago. Vestiges of creation were indeed known long before that time, but they were variously regarded as freaks of geological formation, *lusus naturæ*, as remains of creatures stranded by tidal waves or cataclysms like the traditional flood, or again as the remains of animals formed by a process of spontaneous generation in the depths of the earth that had failed to reach the surface. It was Leonardo da Vinci of the fifteenth century who, anticipating the naturalists of later times, believed these vestiges are what common-sense says they are—simply relics of creatures that lived when the earth was younger. Cuvier was in a true sense the founder of paleontology; though a special creationist, he recognized that beneath their differences there were fundamental likenesses between recent and extinct animals. He assumed that cataclysms had closed the several geologic epochs whereupon new series of animals and plants were created upon the same general working-plans employed in earlier ages; thus he combined the idea of change in geologic time with a belief in supernatural creation. When, however, Lyell led geologists and others to abandon the cataclysmic hypothesis in favor of the doctrine of uniformitarianism, when

the series of known fossil forms increased and the intrinsic value of the paleontological evidence became clearer, the doctrine of evolution finally claimed this field also as its own.

The nature of the case is such that the fossil record must remain incomplete, perhaps forever. For not all the animals of former times possessed hard parts capable of resisting the disintegrating forces of organic and inorganic nature, the rocky tombs of those animals that were embedded in the sands and silts have been crushed and rent asunder by the very geological agencies that at first constructed them. More than half of the earth's surface is now under water, while by no means all of the dry land is accessible. Only a few scratches have been made here and there upon the earth's hard crust, so it is little wonder that the testimony of the rocks is halting and imperfect. But what there is, a rapidly growing body of cold, hard facts, is in itself conclusive evidence of the reality of evolution. Researches like those of Von Zittel, Cope, Hyatt, Marsh, Osborn, and Scott, demonstrate that, when they appear at all, the great groups or *phyla* of animals and their subdivisions succeed one another in that chronological order which comparative anatomy and embryology have independently shown is the order of their evolution. Then too there are those fossil types that link together groups now so widely separated, like *Archaeopteryx*, which is at once a feathered reptile and a bird with reptilian tail and skull and limbs. And there are the marvelously perfect series of fossils like those which demonstrate the evolution of modern horses and elephants; and finally, as the special creationist Louis Agassiz himself showed, some fossil series parallel very closely the embryonic record in modern types. No field opens more invitingly than that of the paleontologist. His tasks are to search the rocks everywhere for new fossil types to fill in the gaps of the lines of

descent that at best can only be interrupted lines, and to show how these lines lead to modern forms or to divergent kinds that have ceased to be. And he will compare his results with those of students in other fields, who will assist him to formulate the working-plans for his own labors.

Zoo-geography is the last branch of structural zoology to attain an independent status. Many observers from Buffon onward had been struck by the fact that species of animals are not uniformly distributed over the earth, that they differ more widely as the observer passes to more and more remote localities, with more different climatic and other environmental conditions. But the meaning of these peculiarities was obscure until the doctrine of descent cleared their vision. Wagner, Louis Agassiz, and Dana, Sclater, Murray, and Wallace were the leaders of those who have brought together the immense mass of modern knowledge of animal distribution. From this many well-established principles relating to descent have been derived, though these have a deeper interest in connection with the dynamic problem as to whether differences in environment can actually cause species to transform, as Lamarck supposed. As a statement of the results in this apparently simple, but really quite complicated field would be misleading, I fear, from its brevity and general form, I will venture to present just one conclusion. Geographical isolation corresponds in a general way with the divergence of species in their evolution from common ancestors; thus widely separated areas have faunas that differ more widely in zoological respects than do those of neighboring or connected countries. For example, the Australian region has been cut off for a relatively long period from neighboring continents, and in correspondence with this isolation it contains the only egg-laying mammals known, as well as all of the pouched mammals like the kangaroo, with a few exceptions like our American opossum. Furthermore, groups

of isolated oceanic islands, like the Galapagos and Azores and the clusters of Polynesia, are inhabited by lizards and birds and insects which resemble most closely the species of the nearest bodies of land. Such resemblances are most reasonably interpreted as indicating that the original progenitors of the island colonies were stragglers from the nearest mainland, whose descendants have undergone divergent evolution during succeeding generations.

Having, then, this vast store of fact and principle amassed through centuries by countless students, the zoologist is entitled to speak positively when he finds a law like the doctrine of evolution that reviews and summarizes the whole range of animal structure. The well-established facts of zoology are the reasons why he asserts with a decision often mistaken for dogmatism that evolution is a real process. The further question, why is nature so constituted that evolution is true, is an enquiry that does not fall within the limits of zoological science.

We now come to the second great division of zoology, which as a whole is concerned with broad and deep enquiry into the workings of nature; it is natural history in the best sense. Prior to the time of Darwin attempts to solve the kinetic problems of the organic world were hampered by anthropomorphism and narrowness of view, as well as by paucity of facts. But since then, owing to the immense influence of the works of that great naturalist, so much attention has been given to the fundamental problems of life that it is now possible to correlate many principles which describe not only the *fact* of evolution but many of the *factors* as well. And in this modern development wide observation has led so directly to extensive experiment that we may justly characterize the present period as an age of experimental zoology. Just as all the apparently disconnected studies of structural zoology deal with one matter,—evolution,—so in the sphere of experimental zoology

all the radii converge upon the study of the factors and method of species transformation.

We can only mention some of the modern departments which have yielded brilliant results, such as cytology, experimental embryology, experimental fertilization, and regeneration. But we may point out that the general problems in these various fields deal like the problem of evolution itself with an analysis of the internal and external influences that determine the final adult conditions of species. For example, the adult salamander possesses a specific structure, in a state of balance or adaptation, that is the final result of an evolution process up to the present time; this same specific condition is the goal of the changes through which the salamander's egg and embryo pass in development; it is the goal also that may be reached by even a portion of a divided salamander's egg; while finally it is the goal of the regenerative processes that enable a salamander from which a leg has been cut off to reproduce the missing part. Everything centers then about the question as to the origin of adult specific forms, which exhibit adaptation.

Realizing this, we may pass on immediately to consider how through the study of adaptation, Darwin was led to formulate his potent theories, which have been the basis for recent progress. As the other speakers upon biological sciences have already stated, the most striking feature of animals and plants is their adjustment to their vital conditions. An organism that seems so sufficient unto itself, so capable and independent, is nevertheless inextricably interlocked with its surroundings, for its very substance is composed of materials which with their endowments of energy have been wrested from the environment. An animal that is pressed upon by the substances of the outer world, that is played upon by various energies, and is attacked on all sides by innumerable foes, finds itself in-

volved in a warfare that is tragically one-sided; and it must prevail over all its many foes or it must acknowledge defeat and pay the penalty for unconditional surrender, which is death,—so stern and unyielding is that vast totality we individualize as the environment. The generalized biological formula, then, for the turmoil of nature is *adaptation = life*.

Here then is the heart of the mystery. How has this universal condition of adaptation been brought about? What have animals within them that might determine their greater or less efficiency? What external influences, if any, are capable of directing the efforts of living creatures to meet their enemies? How are modifications perpetuated when they have arisen? To many of these questions Darwin, Weismann, Mendel, De Vries, and others have found answers, not complete or perfect, it is true, but they have relegated to the past the former reply that supernatural causes must be invoked to account for nature. Science is convinced that the study of nature's workings at the present time reveals natural factors which are competent to account for much of the wonderful process of evolution.

As everyone knows, the works of Darwin inaugurated our recent era in biology. In 1858, Darwin and Wallace announced the doctrine of natural selection, and in 1859, Darwin published the "Origin of Species," a book that has proved a veritable Magna Charta of intellectual liberties, for as no other single document before or since it has released the thoughts of men from the trammels of unreasoned conservatism and dogmatism. And its influence has been felt far beyond the borders of biological science—it has extended to the very confines of organized knowledge everywhere. But it is a mistaken popular notion, and one of the hardest to drive from the mind of the layman in science, that Darwin founded the doctrine of evolution by the book

mentioned and those that followed. The fact of evolutionary descent had been established long before, while even some of the special points of Darwin's theories as to method had been anticipated. Had Darwin never lived, I believe that evolution would still be accepted and taught at the present day. But Darwin rendered two immortal services to science. During the twenty years that elapsed between the first conception of his theories and the date of their publication, he marshalled in orderly array all the biological data obtainable which proved the transformation of species, including the previously unrecognized body of evidence afforded by the domesticated animals. In the second place, in his doctrine of natural selection he presented for the first time a partial consistent program of nature's method of accomplishing evolution. Darwin did not believe that this explanation was final or even complete, whatever his opponents of the time or critics of the present might contend.

What now, is the doctrine of natural selection, as Darwin propounded it? All animals vary; every individual differs from others of its kind, even from its closest kin and from its parents in some or many particulars and to different degrees. Whatever the causes, the fact of variation stands unquestioned. Some variations are of course due to direct environmental influence, and to these Buffon attributed an excessive importance; other deviations from the parental or average specific type are no doubt due to indirect effects of the environment, as Lamarck contended. But there are countless other variations that cannot be so explained, some of them indeed appearing before an individual is subjected to the action of the environment, and these are the congenital variations due to some constitutional even if unknown causes. These seemed to Darwin to be the most important in evolution.

The second element of the doctrine is that over-produc-

tion, or rather over-*re*production, is a universal characteristic of living things. The normal rate of multiplication is such that any given form of animal or plant would cumber the earth or fill the sea in a relatively brief period of time. We now know that a bacillus less than $\frac{1}{5000}$ of an inch in length multiplies under normal conditions at a rate that would cause the offspring of a single individual to fill the ocean to the depth of a mile in five days. "Slow-breeding man," wrote Darwin, "has doubled in the past twenty-five years." But excessive multiplication is checked by the third part of the whole process, namely, the struggle for existence, that fierce unequal warfare waged by every individual with its inorganic surroundings, with other species of living things, and with others of its own kind. Indeed where members of the same species compete, the struggle often surpasses in ferocity the warfare with other organisms. Communal organisms only are in part exceptions, for in these the battle involves the clash of community with community more than it does the interests of the individuals of a single colony. To what, now, do these elemental processes lead, asks Darwin. Though all seek to maintain themselves, all cannot possibly live when only a few can find sustenance or can escape their enemies. Naturally those which possess any advantage whatsoever, that vary ever so slightly in the direction of better adjustment would survive where their brethren perish. And this is nature's selective process, with its positive and negative aspects—the survival of the fittest and the elimination of the unfit. Now we can see why adaptation is a universal characteristic of species—there are no unadapted. If such there were, they have fallen long ago, and the world knows them no more. True it is that perfection is not attained by any creature, but it must establish a *modus vivendi* or it perishes. Thus, Darwin held, nature perfects species by dealing directly with favoring derivations that

are mainly congenital, and so through these it selects the hereditary factors that determine favorable variations.

In one fundamental respect the doctrine is incomplete, as it fails to explain the causes for the variations with which selection deals. It accounts for the perpetuation of favoring variations, but it does not account for their inception. Because of this defect, investigators reacted from the academic discussion of Darwin's original doctrine, and returned to deeper and wider study of heredity and variation with brilliant success. Some neo-Darwinians have endeavored to make the selective process an originaive influence—notably Roux, and Weismann in his theory of germinal selection. Darwin himself added the subsidiary process of sexual selection, which regards the preference by one sex of characteristics of the opposite sex as a conserving influence. But while such attempts have failed, zoologists believe, to explain the whole method of evolution, much of the process has been demonstrated more and more clearly with further study. The laws of fluctuating variations have now been formulated with mathematical accuracy, through the employment of the statistical methods used earlier by anthropologists like Quetelet. The studies of Galton, and Pearson, Boas, Weldon, and Davenport have demonstrated that structural and physiological characters of men, of other animals, and of plants as well, vary according to the formulas of chance or error, —a result they say that follows from the combined influence of innumerable and independent factors. Variation is a natural phenomenon of chance. Furthermore, the reality of the selective process has also been proved by statistical methods. Bumpus' English sparrows, Weldon's snails and crabs, and many other cases show that the individuals which depart widely from an average condition, or that are uncorrelated in their organization, are marked for destruction.

In brief, while natural selection has not been established as in any sense an originaive process, it has been demonstrated, I believe, as a judicial process. For we may liken the many varied vital conditions to jurymen, before whom every organism must present itself for judgment; and a unanimous verdict of complete or at least partial approval must be rendered, or the organism must perish.

The phenomena of biological inheritance, however, have demanded the greater attention of Darwinian and post-Darwinian investigators. A complete statement of the whole of evolution must show how species maintain the same general characteristics through inheritance, how the type is held true with passing generations, and it must also show how new characters may enter into the heritage of any species to be transmitted as organisms transform in evolution.

The earliest naturalists had accepted the fact of inheritance as self-sufficient. The resemblance between parent and offspring did not demand an explanation any more than variation. When Buffon, however, added the element of species transformation, he held that external influences could bring about a directly responsive organic change, which he assumed was inherited. Lamarck developed the well-known view, previously advocated by Erasmus Darwin, that indirect responses to the environment could be fixed in inheritance as so-called "acquired characters," meaning by this phrase that such characters are acquisitions during the life-time of an individual as the effects of disuse or unusual use, or of new habits. Coming again to Darwin, we find that he endeavored to support Lamarck's doctrine and to supplement his doctrine of selection by adding the theory of pangenesis. According to this every cell of every tissue and organ of the body produces minute particles called gemmules, which partake of the characters of the cells that produce them. The

gemmules were supposed to be transported throughout the entire body, and to congregate in the germ-cells, which would be in a sense minute editions of the body which bears them, and would so be capable of producing the same kind of a body. If true, this view would lead to the acceptance of Lamarck's or even Buffon's doctrine, for changes induced in any organ by other than congenital factors could be impressed upon the germ-cell, and would then be transported together with the original specific characters to future generations. Darwin was indeed a good Lamarckian.

But the researches of post-Darwinians, and especially those of the students of cellular phenomena, have demonstrated that such a view has no real basis in fact. Many naturalists like Naegeli and Wiesner were convinced that there was a specific substance concerned with hereditary qualities as in a larger way protoplasm is the physical basis of life. It remained for Weismann to identify this theoretical substance with a specific part of the cell, namely, the deeply-staining substance, or chromatin, contained in the nucleus of every cell. Bringing together the accumulating observations of the numerous cytologists of his time, and utilizing them for the development of his somewhat speculative theories, Weismann published in 1882 a volume called "The Germ-Plasm," which is an immortal foundation for the later work on inheritance. The essential principles of the germ-plasm theory are somewhat as follows: The chromatin of the nucleus contains the determinants of hereditary qualities. In reproduction, the male sex-cell, which is scarcely more than a minute mass of chromatin provided with a thin coat of protoplasm and a motile organ, fuses with the egg, and the nuclei of the two cells unite to form a double body, which contains equal contributions of chromatin from the two parental organisms. This gives the physical basis for paternal inheri-

tance as well as for maternal inheritance, and it shows why they may be of the same or equivalent degree. When, now, the egg divides, at the first and later cleavages, the chromatin masses or chromosomes contained in the double nucleus are split lengthwise and the twin portions separate to go into the nuclei of the daughter cells. As the same process seems to hold for all the later divisions of the cleavage-cells whose products are destined to be the various tissue elements of the adult body, it follows that all tissue-cells would contain chromatin determinants derived equally from the male and female parents. As of course only the germ-cells of an adult organism pass on to form later generations, and as their content of chromatin is derived not from the sister-organs of the body but from the original fertilized egg, there is a direct stream of the germ-plasm which flows continuously from germ-cell to germ-cell through succeeding generations. This stream, be it noted, does not flow circuitously from egg to adult and then to new germ-cells, but it is direct and continuous, and apparently it cannot pick up any of the body-changes of an acquired nature; indeed, it is doubtful whether such changes can reach the germ-cells at all, for the path is not traversed in that retrograde direction.

It must be clear, I am sure, that this theory supplements natural selection, as it describes the physical basis of inheritance, it demonstrates the efficiency of congenital or germ-plasmal factors of variation in contrast with the Lamarckian factors, and finally in the way that in the view of Weismann it accounts for the origin of variations as the result of the commingling of two differing parental streams of germ-plasm.

At first, for many reasons Weismann's theories did not meet with general acceptance, but during recent years there has been a marked return to many of his positions, mainly as the result of further cytological discov-

eries, and of the formulation of Mendel's Law and of De Vries' Mutation Theory. The first-named law was propounded by Gregor Mendel on the basis of extensive experiments upon plants conducted during many years, from 1860 on, in the obscurity of his monastery garden at Altbrünn, in Germany. It was rescued from oblivion by De Vries who found it buried in a mass of literature and brought it to light when he published his renowned Mutation Theory in 1901. Mendelian phenomena of inheritance, confirmed and extended by numerous workers with plants and animals, prove that in many cases portions of streams of germ-plasm that combine to form the hereditary content of organisms may retain their individuality during embryonic and later development, and that they may emerge in their original purity when the germ-cells destined to form a later generation undergo the preparatory processes called maturation. They demonstrate also the apparent chance nature of the phenomena of inheritance. I think the most striking and significant result in this field is the proof that a particular chromosome or chromatin mass determines a particular character of an adult organism, which is quite a different matter from the reference of all the hereditary characters to all of the chromatin. Professor Wilson has brought forward the convincing data showing that the complex character of sex in insects actually resides in or is determined by particular and definite masses of this wonderful basis of inheritance.

Mendel's principles also account in the most remarkable way for many previously obscure phenomena, such as reversion, and again, the case where a child resembles its grandparent more than either of its parents; these seem to be due, so to speak, to the rise to the surface of a hidden stream of germ-plasm that had flowed for one or many generations beneath its accompanying currents. I believe that the law is replacing more and more the laws of Gal-

ton and Pearson, formulated as statistical summaries of certain phenomena of human inheritance taken *en masse*. According to Galton's celebrated law of ancestral inheritance, the qualities of any organism are determined to the extent of a certain fraction by its two parents taken together as a mid-parent, that a smaller definite fraction is contributed by the grandparents taken together as a mid-grandparent, and so on to earlier generations. But Mendel's Law has far greater definiteness, it explains more accurately the cases of alternative inheritance, and it may be shown to hold for blended and mosaic inheritance as well.

De Vries' Mutation Theory has already been explained in an earlier address by Professor Richards. It is clearly not an alternative but a complementary theory to Natural Selection, the Germ-Plasm and Mendelian Theories. Like these last, it emphasizes the importance of the congenital hereditary qualities contained in the germ-plasm, though unlike the Darwinian doctrine it shows that sometimes new forms may arise by sudden leaps and not necessarily by the slow and gradual accumulation of slight modifications or fluctuations. The mutants like any other variants must present themselves before the jury of environmental circumstances, which passes judgment upon their condition of adaptation, and they too must abide by the verdict that means life or death.

From what has been said of these post-Darwinian discoveries, the Lamarckian doctrine, which teaches that acquired non-congenital characters are transmitted, seems to be ruled out. I would not lead you to believe that the matter is settled. I would say only that the non-transmission of racial mutilations, negative breeding experiments upon mutilated rats and mice, the results of further study of supposedly transmitted immunity to poisons—that all these have led zoologists to render the verdict of "not proved." The future may bring to light positive evidence,

and cases like Brown-Séquard's guinea pigs, and results like those of MacDougal with plants and of Tower with beetles may lead us to alter the opinion stated. But as it stands now most investigators hold that there are strong general grounds for disbelief in the principle, and also that it lacks experimental proof.

The explanation of natural evolution given by Darwinism and the principles of Weismann, Mendel and De Vries, still fails to solve the mystery completely, and appeal has been made to other agencies, even to teleology and to "unknown" and "unknowable" causes as well as to circumstantial factors. A combination of Lamarckian and Darwinian factors has been proposed by Lloyd Morgan, Mark Baldwin, and Professor Osborn, in the Theory of Organic Selection. The Theory of Orthogenesis propounded by Naegeli and Eimer, now gaining much ground, holds that evolution takes place in direct lines of progressive modification, and is not the result of apparent chance. Of these and similar theories, all we can say is that if they are true, they are not so well-substantiated as the ones we have reviewed at greater length.

The task of experimental zoology is to work more extensively and deeply upon inheritance and variation, combining the methods and results of cellular biology, biometrics, and experimental breeding. We may safely predict that great advances will be made during the next few years in analyzing the method of evolution; and that a few decades hence men will look back to the present time as a period of transition like the era of re-awakened interest and renewed investigation that followed the appearance of the "Origin of Species."

WE must now state distinctly and fairly the present views of science regarding man's place in nature. Surely

human evolution is a subject that falls within the scope of zoological investigation, unless indeed it can be shown that the human species is exempt from the control of those laws of nature that hold sway over the animate world elsewhere, unless something can be found which excludes man from the animal kingdom. Notwithstanding the most prolonged search not only by zoologists but as well by those who have been unfriendly to the doctrine of descent, the study of man and of men has revealed nothing essentially unique. What is known of the anatomy, development and fossil relations of man is summarized in the statement that he belongs to the genus and species *Homo sapiens*, placed with the apes and some other forms in the order primates because of agreement in certain peculiar details. The primates agree with the carnivora, rodents and many other orders in the characteristics of the class mammalia, which in turn is only a branch of the limb vertebrata or chordata, which also bears the avian, reptilian, amphibian and fish branches. And all the vertebrates including man agree with the varied groups of invertebrates in their cellular constitution and in the similar protoplasmic basis of life. As in these structural respects, so in physiological activities and in environmental relations the human species proves more surely with increased knowledge to be only one of the terms in the extensive series of animals. Indeed, the scientific monism of Haeckel and Clifford ventures to assert that man and all other living creatures are one with the mind-stuff of the inorganic world—and this, I believe, is only the logical extension of the genetic and mechanistic hypotheses. However this may be, science holds that human structure is animal structure, and that human lives are biological phenomena.

Man is structurally inferior in many respects to some of his zoological relatives—he is a degenerate, indeed, in many parts of the alimentary, muscular and skeletal sys-

tems—yet he finds in the higher development of his nervous system an advantage that offsets the weaknesses of his constitution elsewhere. He holds his supreme place by virtue only of superior and more effective control of his organization.

Behind their seeming structural differences, only one real distinction can be found to separate man from the apes—the higher development of the brain. The erect posture, the correlated modifications of skeletal and muscular structures, and apparently the powers of speech and reason, seem to be dependent upon the enlargement of this organ, which, so to speak, has pushed the face around under the brain-case. Therefore he who would be *ὁ ἄνθρωπος*—he who looks ahead—must needs stand erect in order to prevent his eyes from looking straight into the ground. But the most careful analysis has so far failed to detect any essential differences in either structural or functional respects between the human brain and the corresponding organs of the higher apes. In brief, then, differences in degree and not in kind or category seem to distinguish man from the apes—as far as science goes.

Moreover, the human body is a veritable museum of rare and interesting relics of antiquity—the useless vestiges and rudiments of structures that are more developed in other animals. The complete coat of hair of the embryo, the disappearing thirteenth rib, the ape-like and transitory clasping muscle of the new born infant's hand, the curvature of the lower limb and the hand-like foot of the embryo, these and scores of other characters are mutely eloquent witnesses to the past history of change that has brought man to his present place in nature. Embryology gives a vast amount of additional independent testimony. For like all embryo mammals and birds and reptiles, the human embryo possesses gill-slits, and fish-like heart and brain. Above all it begins life as a single cell. Zo-

ology asks:—What can these things mean, if they do *not* mean evolution and a common ancestry with other forms? The objection that no one has ever seen a one-celled organism evolve into a many-celled one, or into a fish or an ape, or into a man, the zoologist answers by placing upon the table the evidence that a single-cell, the human egg, actually does compass the whole history in becoming the almost inconceivably complex adult organism. The process *can* take place for it *does* take place. Paleontology also presents evidence relating to the history of our species, as the third support of the tripod upon which rests the doctrine of human evolution. While opinions differ with respect to the remains of man taken from the many caves and mounds of Europe and America, there is but one generally accepted view regarding the ape-man *Pithecanthropus* of the Javan rocks. The remains of this animal prove among other things that its brain was intermediate between the average ape brain and the average human brain, that the animal was indeed an ape-man and nothing else.

Science holds furthermore that natural factors alone have brought about human evolution. While it is true that the explanation is no more complete for this special instance than it is for animals in general, yet the human species is not exempt from the control of the known factors, like those which cause variation or govern inheritance. Indeed some of the significant facts of heredity have been first made out in the human species. Can we doubt the reality of selection and the struggle for existence when scores perish annually in the conflict with extreme degrees of temperature and other environmental forces, when as a result of the unceasing combat with bacterial enemies alone the casualties on the human side number in our country more than a hundred thousand annually?

To the zoologist it seems strange that there is so much opposition to the doctrine of human evolution. In truth

he finds this to be proportional to misunderstanding of the facts, for when the evidence is produced—Pelion piled on Ossa—any lingering doubts the observer might have are crushed by an irresistible weight of testimony. After all, our kind is but one of the many hundreds of thousands of living species; and viewing the matter from the calm, impersonal standpoint of scientific study, the fact that he is himself a human being does not distort the investigator's vision, for his perspective is corrected and rectified by the instruments of scientific method. He finds no difficulty in accepting human evolution as a scientific fact—that is, true as far as science goes.

IN extending its broad comparative studies into the field of complex and intricate human nature, zoology touches numerous other sciences that might seem at first sight to be entirely independent, or at the most only casually connected with it. I shall venture to point out where analysis within the field of zoology has produced results which have a high and immediate value for students of anthropology, psychology, sociology and ethics.

When they deal with the evolution of the human species from pre-human animals, the anthropologist and the zoologist are brought by their similar interest upon common ground; and when they pass on to explore the field of human diversity where lie the complex problems of racial evolution, they are still fellow-workers, for in the case of physical anthropology of human races at least the methods are the same which are employed in zoology generally. Of course it would be absurd for anyone to contend that all the problems of anthropology are strictly zoological questions; to qualify here an investigator must be familiar with linguistics, racial customs and beliefs, and many subjects that are as such apparently outside the

limits of zoology. But unless a sharp line is to be drawn between the slow origin by evolution of the human species and the later history of this species, the comparative and genetic methods of analysis which render the earlier process intelligible can scarcely fail to be of service in dealing with the latter. The great danger, which the zoologist himself clearly sees, arises from a tendency to ignore the detail in formulating the general, to oversimplify the problems of the more recent history. For human conscious elements are so complex and plastic that the problems of racial evolution are rendered far more intricate than the broad zoological analysis of the origin of man as a species.

Psychology, in the second place, is a subject that is related to zoology by the closest of ties, the bond of union being again the common human element. To be sure the zoologist finds enough in his own field to occupy him fully, but the comparative study of nervous systems, and of the reflex, instinctive, intelligent, and reasoned responses of animals brings him inevitably to consider the relation of human mentality and consciousness to the other terms of the animal series. Dealing strictly as a zoologist with animals and their lives, the investigator learns that the machine-like regularity of reflex and instinctive activities is correlated, broadly speaking, with simple nervous organization; that the plasticity of intelligent response is not gained until the physical basis becomes far more complicated; and finally that reason and consciousness are in some way bound up with the higher development of the nerve-centers or ganglia that make up the brain. So the zoologist is inclined to believe that the comparative series of mental grades which culminates in the consciousness, or rather the self-consciousness of the adult human organism, and the series of developmental stages through which the human mental structure passes during infancy and

childhood, indicate an evolution in time of the psychic being of man. Whatever may be the outcome of further study, Romanes, Lloyd Morgan, Forel and Thorndike, among those of modern times, have demonstrated that the genetic methods of zoology are useful instruments for the psychologist, who, I believe, is becoming more and more a student of zoological materials as he realizes the advantage of studying the simpler psychic phenomena of animals lower than man.

In venturing to speak of the relation of zoology to sociology and ethics, I am well aware that I shall be charged with straying beyond the confines of my subject. But if the student of lower forms should find well-defined principles of biological association and principles of animal conduct, it is not only his privilege, it is in a sense his duty as well to bring these to the consideration of the students of human social and ethical relations. Unless in these matters there has been a break in the continuity of evolution, the simpler relations to be observed in lower animals must surely possess a profound interest—and perhaps more.

In a true sense, any of the many-celled animals is a community, whose constituent members are the differentiated tissue-cells, which have undertaken the various tasks of digestion, contraction, sensation, and the rest. By far the majority of animals are cell-communities of this nature. Considering these as individuals, though of a secondary order, we find some communities made up of several animals which have banded together for mutual support and defense, giving us as in the wolf-pack a counterpart of the lowest associations of savage men. But among insects especially we find colonies of numerous multicellular individuals which may be so rigidly specialized for the performance of certain tasks that we cannot avoid the use of terms applied to civilized human groups

in describing their differentiation and division of labor. Some colonies of bees comprise queens and drones and only one kind of sterile workers, though when newly hatched these last serve as guards and nurses, taking the field as foragers for pollen and honey only later in life. In various ant-colonies we will find workers who serve as herdsmen, devoting their time to the care of the ant-cattle or aphids; again there are masons, and gardeners, and carpenters, and soldiers of various ranks, while in the honey-ant some individuals may serve as living receptacles for the tribal stores of food. Each kind undertakes one of the tasks that are vital for the life of the community as a whole. Instinctive and unreasoned their activities may be, and undoubtedly are, but the economic and social relations of the component members of the colony are strikingly analogous to certain fundamental phenomena of human societies. But still more wonderful are the cases that may be found among hornets and wasps. A fertile female overwinters and places her first-laid eggs in the chambers of a simple nest that she constructs herself. When the young of the first brood hatch, she provides them with food, enlarges the nest, and continues the task of egg-laying, while her first offspring relieve her of her former duties as they become able. They enlarge the nest, they care for their younger kin as they hatch, they forage abroad for the food-supplies for the colony. And so the community that begins life in the early spring with a solitary animal advances during the passing weeks to a degree of complexity that is truly astounding. As an epitome of insect social evolution it gives in a few weeks a review of the process that in other forms of social insects with stable colonies, or in the analogous human history, has demanded centuries of time.

As we review these different kinds of individuals—the one-celled animal, the many-celled creature and the community,—we see that each one must obey certain rules of

nature. It must preserve itself, it must perpetuate its kind, and, if it be a member of a higher community, it must act in the interests of others and of the whole group. Do we not find, then, biological definitions of right, and evil, and duty to others as well as to self? Do we not see why altruism has grown out of egoism as communities have evolved at the behest of nature?

But still, facts like these are purely zoological facts. To be well within his rights, the zoologist should perhaps only suggest their usefulness for the analysis of human social relations and obligations. It is for the sociologist and the student of comparative ethics to employ and apply them according to the principles of the genetic method, should they see fit to do so.

IN closing, may I say a few words regarding the attitude of the zoologist toward his problems and his results. He may maintain this attitude because of a certain temperament which leads him and his fellows to enter the field of science as investigators. While this may be true, it is also true, I believe, that the subjects of their study, the principles they may discern in nature's order, and their methods of analysis have a profound reflex effect upon not only the contents of their minds but upon their mental machinery as well. The zoologist, like his fellow men of science, learns early that he must adopt an impersonal attitude, for emotion and purely human interest are disturbing elements that prevent him from attaining the purpose of the investigator—which is, to ascertain and verify facts, to classify them logically, so as to derive from them the summaries which like so much “conceptual short-hand” are available for others as well as himself. Science is “organized knowledge,” as Pearson defines it; “organized common sense” in Huxley's phrase; and like other men of science the

zoologist learns to view his great common-sensible principles like the doctrine of descent, not as absolute eternal verities, but only as summaries up to date, as working programs, to employ Professor Wilson's concise phrase. This *may* be pragmatism; it is certainly science.

But surely this does not mean that principles like the one mentioned are so many gratuitous assumptions. Like the principle of gravitation and the law of the conservation of energy, zoological laws have the strength and approximate finality of all the wide range of facts that they summarize. And these are many—a vast store of detail and generalization accumulated during decades and centuries by those who have sought upon the mountains or in the abysses of the seas for new knowledge, by countless students who have spent their lives in the field and in the laboratory in the endeavor to pierce still further with trained insight into the mysteries of nature. And these are their results.

No one realizes more than the zoologist that his knowledge is incomplete. No one can see more clearly than he that his intellect evolves, like the great sweeping tide of things and events—the nature he studies and of which he is but a conscious atom. The investigator soon learns to withhold final judgment, agreeing with Clifford that the primary conditions for intellectual development are the plasticity and openness of mind that dogmatism and finality destroy. The end of zoology cannot be until the end of all knowledge.

Conscious then of the impossibility of reaching absolutely final knowledge, why does the investigator continue to search the world of nature as he does? Because of that ingrained and insatiable human curiosity to learn, because of the human discontent with the attained. Antaeus-like, every fresh contact with the world of law and order infuses new energy into his veins for further endeavor. “Und es treibt und reisst ihn fort, rastlos fort . . . ” not, it is true,

in the wandering blindness of Schiller's huntsman, for his human vision is aided by the instrument of scientific method with which he can *almost* perceive the infinitely great and the infinitely small.

Glorying in the great achievements of his science, reveling like the mathematician in the ordered assemblage of related and organized knowledge, the student of zoology joins his fellows yet again for a renewed attack upon the distant ramparts of the unknown, deriving courage and inspiration from the motto: *Ignoramus, in hoc signo laboremus*.

ANTHROPOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
DECEMBER 18, 1907**



ANTHROPOLOGY

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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published February, 1908.

ANTHROPOLOGY

IN attempting to set forth briefly the principal results of anthropological research, I find my task beset with many difficulties. If the clear enunciation of the aims and methods of physical or biological science is not an easy matter, difficulties many times greater are encountered in an attempt to explain the present position of investigation dealing with mankind from the biological, geographical, and psychological points of view,—subjects that seem to lack in unity, and that present a number of most divergent aspects. Owing to the apparent heterogeneity of method, it seems necessary to explain the aims that unify the many lines of anthropological research. I can then proceed to describe what little has been attained, and how we hope to make further progress.

We do not discuss the anatomical, physiological, and mental characteristics of man considered as an individual; but we are interested in the diversity of these traits in groups of men found in different geographical areas and in different social classes. It is our task to inquire into the causes that have brought about the observed differentiation, and to investigate the sequence of events that have led to the establishment of the multifarious forms of human life. In other words, we are interested in anatomical and mental characteristics in so far as they are peculiar to groups of men living under the same biological, geographical, and social environment, and as determined by their past. Thus we are concerned with the effects of the climate and prod-

ever, often be cases where a written record bears so close a relation to a material monument of the past as to become wholly archaeological in character, and, on the other hand, there may be material monuments which are so closely bound up with the history of a people that they cannot be thought of as separate from that history. So a general definition is rather apt to break down when it comes to details and we have to be content with some inexactness. Such a state of affairs is pretty sure to arise in connection with any subject which deals specifically with man's varied social activities, and the material objects which result from his activities will naturally be as varied as the activities themselves. It is indeed an old question whether we ought to call such subjects as archaeology and history sciences at all, since they do not admit of the logical analysis which we like to associate with the term. There seems, however, no great gain in so limiting the connotation of the word "science," and at any rate archaeology and history may certainly be studied scientifically.

For practical purposes, then, we may accept such a definition of archaeology as has been given in Hogarth's "Authority and Archaeology," namely that it is the "science of the treatment of the material remains of the human past." But even such a definition assigns to the subject an enormous domain, and we at once see that it must inevitably be broken up into innumerable specialties. In the first place, there are the ethnic divisions in bewildering variety. Among primitive peoples, even when they may dwell in different parts of the earth, the study of archaeology may take on a not very dissimilar character, though, on the other hand, climate and race often introduce great variety. But when a people has reached a rather high state of civilization, as the Egyptians, for example, and the Greeks did, the situation is very different. Here we are confronted with all the complexity which comes from elab-

orate social organization and high artistic development, and this organization and development will assume different forms of course, in accordance with determining conditions of race, inheritance and history. We may say that a person who is studying the Pueblo Indians of New Mexico and Arizona and one who is studying some problem in Athenian life of the fifth or fourth century B.C. are both working at archaeology, but it is obvious that their activities are of a very different nature. The archaeology of the one stands very close to anthropology, that of the other to the history of an advanced civilization and art. Such contrasts in the nature of the study suggest the two-fold direction which it naturally takes, according as it is concerned with peoples that are known through the medium of literature and history, or with such as have left behind them only the unwritten records of their art or handicraft. In the latter case, archaeology is of course a much more independent branch of learning than in the former, but its conclusions would naturally often be much strengthened, if they could be supported or corrected by the evidence of written documents; in the former case, it becomes more or less a branch of history, in proportion to the extent and the definiteness of the knowledge which the written records furnish. The archaeology of primitive peoples naturally deals with social conditions that involve no written records, but there are instances where we are forced to gain our conception of highly developed civilizations almost entirely through the material remains which survive them. The study of Egypt is an example of archaeological work of this kind, for its written records are of course chiefly supplementary in character.

It is interesting to contrast the conception which is formed of the civilization of ancient Egypt with that which may be had of ancient Greece where archaeological study goes hand in hand with the extensive knowledge that

comes from written history and from a great literature. In spite of the enormous amount of archaeological material in Egypt, the idea which can be gained of the life of the ancient Egyptians seems shadowy and external to us in the absence of extended written records. We may see evidence of dynastic changes, of an all-powerful hierarchy, of attempted religious reforms, of the management of great agricultural estates in the Nile valley, and we may know with astonishing minuteness the material implements and setting of everyday life, but we do not know that life in any really sympathetic way. Its thoughts, its ideals, its strivings are lost to us in the lapse of centuries. With Greece, on the other hand, it is very different. Archaeologically it is certainly not better known to us than Egypt, but we may go with the Greek into his political assemblies, to his law-courts and his market-place, to his theatre and his athletic games. We can hear him talk of his art and his religion and his poetry. In other words we can know him in almost the way that we may know a contemporary civilization.

I shall have more to say about the part that archaeology plays in the vivid picture we get of Greece, but just now I merely want to emphasize the difference between the type of the study when it is concerned with a people that has left written records, and with one that has not done so—between the independent archaeology and that which is a branch of history.

It is, however, not solely through differences in race and inheritance, or by reason of the different stages of man's advancement in civilization, or because of the presence or absence of written records, that the nature of archaeological study tends to vary so greatly. When any one civilization is sufficiently advanced to become complex, its archaeological records naturally grow so varied that the study of them branches out in very different directions, and hence

tends to become specialized, even within the boundaries of the civilization itself. To investigate the various domestic arrangements in a Mycenaean palace or the drainage of a house in Pompeii is a work the quality of which is different from an investigation that brings the student into contact with the development of higher forms of artistic expression. It is not only that an aesthetic element enters at this point into the study; there is also a higher intellectual quality in it. I would not seem to belittle at all the humbler material affairs of life through which the great body of archaeological knowledge must be built up. Under any truly scientific ideal, all these things must be studied in minute detail, for though they may have little inherent importance, they are of great value in rendering our conception of a past civilization real and sympathetic; but they are subordinate facts. When, however, the student is brought into contact with the artistic products of some gifted people, the subjects at which he works do have an importance that is inherent, and it is when archaeology takes this direction that it is of real educational value. It becomes the foundation for the history of art, and passes imperceptibly into this latter subject. This is the kind of archaeology which has its centres of study chiefly in universities and museums, though it of course ultimately owes its existence and much of its progress to the worker in the field.

This fact upon which I have thus far laid such special emphasis, namely the very diverse character of archaeological study, will, I hope, make it plain that no ordinary individual could possibly discuss the details of the science as a whole with any real authority. Certainly I cannot attempt to do so, and I shall therefore confine myself from now on to a presentation of some phases of Greek archaeology which, though they will of course relate to a single ethnic division of the science, may nevertheless be thought

of as somewhat typical of the whole. Apart, however, from the obvious necessity of discussing the portions of a subject which fall within the range of one's knowledge, Greek archaeology is a good branch to choose because of its unusual diversity. There are few types of archaeological study which may not find illustration within its ample range.

In the prehistoric period, which includes the so-called Mycenaean civilization with its Aegean and, in Crete, Minoan background reaching well into neolithic times, we have the type of archaeology which is not assisted by written records. To be sure, written characters, hieroglyphic and linear, on seals and clay tablets, were known during a portion of this time, but even if they are eventually deciphered, they could not do more than throw some light on the other archaeological evidence, as is the case with the written records of the Egyptians. Thus the archaeology of this early time in Greek lands is of the independent kind, and some of its problems belong to the anthropologist. After the Mycenaean civilization passes away, about the twelfth century B.C., there succeeds a period when the art is more primitive than that of the Mycenaeans and is characterized by certain marked schemes of geometric decoration. It appears to be a time of much migration among tribes and of a considerable mixing up of the various elements which became more or less closely amalgamated in the rise of the Greek people. In this so-called "Geometric" period we are still in the domain of prehistoric archaeology, for not till its close, which we may place roughly in the eighth century B.C., do we begin to get written records and to see the dawn of the literature of historic Greece. The rise of the Greek Epic, to be sure, goes back farther than this time and the origin of its traditions is probably to be found in the Mycenaean period. I shall allude to this question again; it need not detain us now.

With the close, then, of the "Geometric" period we come to the time when history and literature begin to play an increasingly important rôle in the forming of our conception of Greek civilization. Archaeology is no longer independent, but it does serve to make our idea of Greek life vastly clearer, as I hope to be able to show. It now tends, in accordance with the high artistic gifts of the Greeks, to merge itself in the history of art, a union which of course becomes practically complete where the highest manifestations of Greek art are concerned. Thus the different forms of archaeological study are very fully illustrated in Greek lands.

Let me now seek in a somewhat general way to point out how our conception of ancient Greek civilization has been made clearer by archaeological study, and after that I will give a few definite examples, chosen from the whole field, which may serve to make the general view somewhat clearer. I should be glad, did the time allow, to give an account of the interesting and picturesque history of this branch of Greek study, but I can merely touch upon this point.

The beginning reaches as far back as the journeys in the Levant of Cyriac of Ancona, who visited the Florentine Duke of Athens in the fifteenth century, and we may trace the growth of the study through the establishment in Greece of the French missionaries, Jesuit and Capuchin, and through the work of many travellers, chiefly French and English, who gradually spread abroad a knowledge of the monuments in western Europe. Toward the close of the seventeenth century came the melancholy bombardment of Athens and the destruction of the Parthenon by the troops of the Westphalian Graf von Königsmarck, who was in the employ of the Venetian Republic, then at war with the Turks, for the latter were at that time in possession of Athens. The officers brought back to their homes accounts of what they saw, some of which were illustrated

by their sketches, and this again served to spread a knowledge of Greece. Curiosity to see the country grew, and in the eighteenth century there were more travellers, among whom Stuart, a Scotchman, and Revett, an Englishman, hold the first place, for they stayed many months in Athens and brought back with them drawings, which, though they were not published till many years afterward, were the first actual demonstration to western Europe of the magnificence of the Greek remains. In this same eighteenth century, Winckelmann was laying the foundations for the study of Greek art by his theoretic work, so that early in the last century the scholars of Europe had begun to long for original specimens of Greek sculpture which might take the place in the study of art of the Roman copies in Italian museums. The interest of private collectors, already of course awakened, then grew apace, with the result that valuable antiques were gradually gathered together, especially in England, and these have now in many cases passed into the possession of museums. Then came the revelation of the Elgin marbles, which were not bought for the British Museum till some time after they had reached England. To a modern student it is amazing to think of the testimony before the Parliamentary committee which decided on their purchase. Nothing can show more clearly the lack there was up to that time of any real knowledge of Greek originals. As soon as a clear conception of the art of the Phidian period was gained through these wonderful marbles, they became a kind of central point from which archaeologists could build up an idea of the course of the sculptor's art in Greece both backward and forward. Thus by the middle of the last century everything was ready for the great excavations which have been the characteristic of the past fifty years and which have created the splendid museums of Athens, Olympia and Delphi, and have enriched those of western Eu-

rope and of our own country, not only with many fine specimens of sculpture, but also with no less interesting and important examples of the industrial art of the Greeks. Finally, what is perhaps historically the most picturesque feature in the growth of Greek archaeology, and in itself an amazing fact, the leading nations of the world, France, Germany, our own country through leading universities and colleges, England through friends of Hellenic study, and Austria, have made Athens once more a university town by the establishment there of national archaeological schools.

From this brief historical digression I will now return to consider first very generally how our conception of Greek civilization has been changed by the growth of archaeological study. It has of course been commonly recognized that in the work of the Greeks are to be found the beginnings of nearly every branch of intellectual activity in the western world, and that they in large measure marked out the categories in which this activity has shown itself. If we want an example from very near home, it is only necessary to call attention to the extraordinarily Platonic method of thought which characterized the first of this series of lectures. The world of scholars has certainly not failed to acknowledge its debt to Greece. But along with this ample acknowledgement, there grew up among persons less well-informed, a popular conception of the ancient Greeks, and this conception, which has been singularly widespread, is very inconsistent with the view that they could have made any large contribution to the spiritual life of mankind. Professor Gilbert Murray, in a recently published lecture, has described most concisely this popular and perverted view to be "a conception of Hellenism as representing some easy-going half animal form of life, untroubled by conscience or ideals, or duties, and the Greeks as a gay, unconscious, hedonistic race, possessing the some-

what superficial merits of extreme good looks and a mythically fine climate." "There is no reason," Professor Murray continues, "to suppose the Greeks miraculously handsome, any more than to suppose that there is no dirty weather in the Aegean." It need not now concern us how this false idea arose or whether Professor Murray is right, as he very likely is, in believing that it grew up through the attribution to the Greeks by ascetic Christian apologists of qualities which afforded an antithesis to their own views and which they erroneously made synonymous with "Paganism." It seems to be one of those perverted notions which often appear in history to obscure our vision of the truth. However that may be, this false view of the Greeks has existed, and one of the things which is putting an end to it, or which has already done so, is the more vivid conception of ancient Greece that archaeology has brought. The setting of our former picture has become much more complete. When one is able to see the products of a civilization in large mass face to face, to become familiar not only with the works of its greater minds, but with those of its humble handicraftsmen as well, one may enter so fully and with such sympathy into the life of the people as to be pretty effectually protected against false and one-sided judgments about them. To take but a single example: Within recent years a large number of sepulchral monuments have been uncovered which have been well published in an extensive *corpus*. It would indeed be a person of dull imagination who could go through the halls of the museum at Athens, where there is an extensive series of these monuments, or who could study the reproductions of the *corpus*, without having a lively sense of that kinship which we all feel in the presence of human sorrow.

There has been, too, another mistaken view of the Greeks, not this time ethical in purport, which has tended to make them seem exceptional in their development, and thus to

stand rather apart from other men. This is the idea of a very sudden efflorescence of their art in all its perfection, not at all after the manner of most human things. Archaeology, however, has shown that the growth of artistic skill, though no doubt rapid, was not abnormally so, and the view which reason should formerly have shown to be the true one is now not open to question.

It would be possible, of course, to pursue this line of thought much further, but it will better meet the present need, I think, if I turn to the consideration of a few of the more important examples of recent development in Greek archaeology, and try to show briefly what their scientific significance is. Such a presentation may, I hope, serve to illustrate, at least by implication, some of the general views that have been expressed, and may suggest more concretely the typical quality of Greek archaeological work.

The beginning is of course naturally to be made with the prehistoric time. The study here has taken on a scientific character comparatively recently, since until Schliemann's excavations the requisite material for study was not at hand. I will not dwell upon the picturesque and interesting incidents in this remarkable man's career, which led him to begin his famous work at Hissarlik with the idea of finding the Homeric Troy. It is easy to smile now at the unscientific character of some of his ideas, but there is nothing to excite anything except admiration when one marks the progress in the quality of his work, and sees his abounding enthusiasm and energy and the large-minded way in which he sought the best advice and help he could get. He certainly found Troy—or a place corresponding to it—though his first interpretation of the excavations was mistaken, and he opened the wonderful graves at Mycenae which amazed the world with their wealth of gold. Later in his work he had the wisdom and good fortune to avail

himself of the coöperation of Professor Wilhelm Dörpfeld, who with consummate skill has continued and perfected the work which Schliemann began. Tiryns too was soon uncovered, with results that were architecturally of especial importance, and the excavations at Hissarlik, which had really never been dropped, were continued further. There was a difficulty in the fact that the objects found at Mycenae did not correspond with those found in the second stratum of the Hissarlik excavations, which Schliemann had believed to be the Homeric Troy. The trouble was soon cleared up, though Schliemann did not live to know the conclusion of the whole matter. The so-called sixth city at Hissarlik, a larger and more important settlement, turned out to be the one which corresponded with the excavations at Mycenae and Tiryns. Schliemann's work has been continued by Dörpfeld and by the Greek Archaeological Society, chiefly under the direction of Tsountas, and thus gradually a large amount of material to illustrate what has come to be called the Mycenaean civilization has been gathered together. Many lesser sites were explored, and it became evident that this civilization extended very generally over the mainland of Greece. Such, in brief, has been the first stage in the investigation of prehistoric Greece.

The second stage will always be associated with the island of Crete and with the name of Dr. Arthur Evans, though many others have had a hand in the work, notably an able company of Italian archaeologists, the British School at Athens, the English archaeologist, Mr. D. G. Hogarth, our own country-woman, Miss Boyd, now Mrs. Hawes, and some others.

Until recently the island of Crete, which appears to have been the chief centre of the Mycenaean civilization, was politically in too unsettled a condition for very extended archaeological work. This, however, did not prevent Dr.

Evans from studying it, and largely through his great knowledge of the small objects, especially the gems, which illustrate the early art of the Aegean, and which have been found in many places, he was led to form conclusions in regard to the probable results of excavation in Crete, which, now that they have been abundantly confirmed, are seen to constitute an extraordinary example of archaeological penetration. Dr. Evans' excavations at Cnosus, near Candia, are the most extensive that have thus far been prosecuted in Crete, but those of the Italians are extremely important also, and they have yielded some of the most interesting specimens of Mycenaean objects. The excavations at Cnosus, however, have revealed a very long chronological sequence, which appears to begin as early as the earlier Egyptian dynasties, toward the beginning, that is, of the fourth millennium B.C., unless indeed a still earlier dynastic dating be accepted. The changes in Cretan art can be traced from this point down to the close of the Mycenaean time, that is, till about the end of the second millennium B.C. To the Greek archaeologist it is the objects which belong to this second millennium that have the most immediate interest, because of their relation to Mycenaean art, but those which are to be dated earlier are of the highest importance to a knowledge of that which lies back of the Mycenaean period. It has already been said that Schliemann found settlements at Hissarlik beneath the one which proved to be the Troy of Mycenaean times, and evidence of this primitive culture has for years past been turning up in the islands of the Aegean. Just now similar phenomena are appearing on the Greek mainland, notably under the ruins of Mycenaean Tiryns, so that a primitive archaeology of the Aegean region is slowly developing. But this is a matter which I must pass by.

The view which archaeologists are at present inclined to take with reference to the Mycenaean civilization is that

one of its greatest centres, probably its greatest centre, was in Crete, and that a period in its course of great influence and power is to be associated with the King Minos who becomes an important figure in later Greek legend. Whether the civilization spread directly from Crete to outlying regions is still a matter for discussion. It was important in Sicily, and its influence reached to far-off Spain, which in its bull-fights appears still to hark back to a favorite Mycenaean sport. Some students of the prehistoric archaeology of northern Europe believe indeed that this Mycenaean influence may be traced far northward into the continent. The regions, however, that were close at hand must have felt this influence most strongly. Thus to understand the ethnic and artistic relations in which this early civilization stands to the Greece of later times is all-important to the Greek archaeologist.

The art of the Mycenaean civilization was in some directions of a very fully developed type. In architecture we find exceedingly elaborate structures, especially in Crete, where the palaces of the chieftains were unfortified, presumably because their owners controlled the seas. On the mainland, the palace at Tiryns shows most distinctly the type of the fortified residence, and here we approach a good deal more closely to the plan of a chieftain's house as it appears in the *Odyssey*. It is clear enough that these residences were often splendidly adorned and were arranged for a life of considerable comfort. Wall paintings of high decorative merit have been found, excellent relief-work in plaster and fine carving in stone, but it is above all the objects of minor art which excite our admiration. Some of the work in gold, silver and bronze has perhaps never been surpassed, and great skill, too, is shown in the relief work on some of the stone vases, and in the carving of ivory and gems. In pottery, too, there is very high development, and great variety, with extremely clever use of

plant forms and of some marine animals in the decorative schemes. A linear script which takes the place of an earlier hieroglyphic writing was known, but it has not yet been deciphered. In general it may be said that the Mycenaean art shows some oriental and especially Egyptian influence, but in the main its character is singularly independent, and it is often startlingly modern, much more so than the Greek art of the classic period. When the human face is represented, it is neither Egyptian nor Semitic in type, and the individuality of the faces is strongly marked. To me it seems that great emphasis should be laid on this tendency to mark the individual. The importance of the individual man is one of the leading social facts of Greek civilization, and one of the features which distinguishes it from the characteristic civilizations of the East. Thus when the differences between the art of Greece and that of the Mycenaeans are emphasized, it is well to keep this fundamental resemblance in mind.

But what is the origin and what are the ethnic relations of this gifted people which has so recently been made known to us? This is a question now being eagerly asked, but as yet it has not been answered. If the writing on seals and clay tablets shall be deciphered, we are likely to know a good deal more than we do now. At present the whole matter is involved in the conflicting traditions regarding the various tribes and peoples which had their homes in Greece before the inhabitants came to be known as Hellenes, for, if anything is certain, it is that the Greeks of historic times were a mixture of various different peoples. The problem becomes closely linked with the intricate question of the origin of the Homeric poems, since in them we have a picture of the heroic, or Achaean civilization which furnishes the background for so much of Greek legendary history. More specifically, the question presents itself to us in this form: Is the Mycenaean art and civilization suf-

ficiently like the art and civilization depicted in the Homeric poems to warrant us in practically identifying the two civilizations? It is not surprising that archaeologists should often disagree in such a matter, and of course the extraordinarily difficult critical problem of the unity of the Homeric picture is also involved. Is it a single picture that the poems give us, or is it a picture of earlier times complicated by the contemporary influence of the poet's surroundings or by the play of his own fancy? Clearly there is plenty of chance for a difference of opinion, and two marked tendencies are observable. The one would emphasize the differences between Homeric art and that of the Mycenaean civilization, the other the resemblances between the two. As matters stand to-day, the view that the Homeric poems reflect in the main the civilization of the Mycenaean period is the prevailing one. The differences, it is thought, may generally be explained by the fact that the poems originated at a later time, and that the picture they give has been somewhat modified by changing customs. Thus the society of the poems has a somewhat more democratic stamp than we should naturally associate with the Mycenaean civilization, and the connection between the Homeric conception of the gods and the religious ideas of the Mycenaean civilization, so far as we can form an idea of them, is not yet clear. Apparently the muse who inspires the poet is a very complicated personality. Emphasize as we will the unity of the poems in their present form, there is still very strong evidence that they are not chronologically homogeneous in all their parts, and this fact must of course warn us to expect a lack of unity in the picture they afford.

When it is sought to associate the Mycenaean remains with one or other of the various peoples or tribes which appear in the Homeric poems and in other Greek tradition, we are face to face with a somewhat different phase of the

problem. For Homer, the Achaeans are the leading race, but we have in Greek tradition conflicting accounts of Pelasgians who were very likely earlier. Homer knows, too, of other races, and in Crete he enumerates many tribes. But so long as we lack the knowledge to form any clear conception of the qualities of these different races, there is no great scientific gain in identifying one or the other with the Mycenaeans. It is always possible, moreover, and very likely, that this wonderful art grew up in the gradual union of tribes of different stock. So, to solve the problem, we must wait for more light.

The relation of Mycenaean art to that of later Greece may, however, be traced in a more distinctly archaeological way, a way that does not involve the uncertainties of vague literary traditions. Here the question is: How far can the influence of Mycenaean design be traced in later art? I have already said that, when this great civilization passed away, at the end of the second millennium B.C., it was succeeded by a period in which artistic design was based chiefly on geometric forms. The art of this period is far less advanced, and we have what has been called the time of the Greek "Dark Ages." Some movement of peoples, very likely the so-called Dorian invasion, put an end to the power of the Mycenaean chieftains, and to the art that their civilization produced; then there was gradually developed an art, ruder in character, which had its basis in the geometric designs that are common enough among all primitive peoples. In other words the geometric art is the outgrowth of a peasant style, a *Bauernstil*, as the Germans call it. In this may be traced some remains of Mycenaean influence, enough, probably, to show that the traditions of that civilization were not quite lost, though investigations in the matter are by no means complete. Another and probably stronger support for this connection between Mycenaean art and that of later Greece lies in the early

art of Ionia, where it would seem that Mycenaean elements have been somewhat more directly preserved. As yet, however, we know comparatively little of the early Ionic remains, and their further discovery and investigation is one of the most important problems in Greek archaeology. To the work, then, of the Greeks of Asia Minor we must look for light on this point, and indeed this region of the Greek world has in many ways become the land of promise for the archaeologist. To take but a single instance: in the Greek art of the seventh and sixth centuries B.C. there are many oriental elements. Where do they come from? Very likely through Lydia and Cappadocia, but the early art of these countries is still very imperfectly known.

This very scant outline of some of the problems which are now before students of prehistoric Greece, must, I fear, suffice for the present purpose, and I will next pass on to consider the results of a typical excavation of the historic period. The work of the Greeks on the Acropolis at Athens during the decade between 1880 and 1890 seems a good example to choose, because of its bearing not only upon the history of sculpture, but also upon that of architecture and upon some of the minor forms of Greek art.

As has already been remarked, through the bringing of the Elgin marbles to London a definite conception of the Phidian art—that is, of the art of Greek sculpture in Attica about the middle of the fifth century B.C.—was gained. Of the earlier development of Athenian art there was practically no knowledge, though some other parts of Greece, notably Aegina, certain regions of Ionia, and Olympia, had yielded sculpture which was clearly earlier in date than the marbles of the Parthenon. Did not Attic art also pass through an archaic stage? There were, to be sure, a few isolated specimens of the early art of Attica, like the figure popularly known as the “Marathonian Soldier,” but these could not be dated with any certainty, and they seemed to

stand unrelated to the subsequent period. In architecture the Parthenon, Propylaea, and Erechtheum of course afforded a good idea of fifth century work, but we knew nothing of the stages through which the art had passed before reaching the perfection of form which these ruins show. In ceramics, archaeologists were even more at sea, and archaic looking vases which showed red figures on a dark ground, the scheme of color that follows the system known as black-figured, were dated well on in the fifth century B.C., in spite of their archaic character. This may seem a slight matter, but to the archaeologist a correct chronology of vases is all-important, since in excavation, the potsherds are often, are indeed commonly, the indication of date. Such, then, in general, was the state of our knowledge—or ignorance—about Attic art, when the excavations on the Acropolis began. From the Greek historians, however, this fact was known, namely, that when Xerxes invaded Greece in 480 B.C. the Persians, just before the battle of Salamis, captured Athens and destroyed the monuments on the Acropolis. Presumably, therefore, the excavators would find at least some record of the art which preceded the Phidian epoch, and it would be fair to assume that objects found in the rubbish used to level the surface of the hill for the builders of the fifth century would be correctly dated at least before 480 B.C. The results of the excavations exceeded the fondest hopes of the archaeologists. A large series of sculptures was found illustrating the art of the Athenians from the beginning of the sixth century B.C., and possibly from a slightly earlier date. Some of these formed pedimental groups and thus showed the existence of several temples much earlier than those that were known. Many architectural fragments were found which have gradually disclosed their meaning, and even to-day students are at work on the remains and are constantly making additions to our knowledge. It would be difficult

to exaggerate the importance of these excavations to an understanding of Greek art. The historical relation of many monuments was at once made clear, and a definite impression of the Athenian art of the sixth century B.C. was created, analogous to that which the Elgin marbles had created for the fifth. Many inscriptions and some important objects in bronze were discovered, and the finding of red-figured vases in the pre-Persian rubbish established the fact that much too late a date had been given for the beginning of the style. Some of the discoveries had also an important mythological bearing, for many of the objects found are related to Athenian legend and cult. Not only is it now possible to know much of several temples on the Acropolis which existed a century and more before the Parthenon, but it has also been revealed that the height was once a stronghold in Mycenaean times, and had, like Tiryns, its chieftain's palace, to which a passage in the *Odyssey* appears to make reference. It is impossible to indicate in a few words the far-reaching scientific and artistic importance of such excavations as these; they throw light in so many ways, not only upon questions immediately before the excavators, but also upon the problems of excavations in other regions. The discoveries, for example, on the Acropolis of early sculptures have an important bearing upon similar finds in the more recent excavations at Delphi.

The next example of recent archaeological progress I will take from ceramics, one of the most important of the various branches of Greek industrial art. I shall confine my remarks to the vases alone, though of course the subject includes all work in moulded clay, and consequently the beautiful and interesting figurines about which there has been so much talk in recent years.

The scientific study of vases is comparatively new, in spite of the fact that the older museums of Europe have

for a long time possessed large collections. The subject is a difficult one, since it includes products which differ greatly in style, and the reciprocal influence of the various styles is still in many cases imperfectly understood. Until rather recently the best known classes of these vases, both black and red-figured, were indiscriminately called Etruscan, and even to-day one sometimes hears this term popularly applied to them. We now know, however, that comparatively few of them are really Etruscan, and these of inferior quality; although found in Italy, they are for the most part Greek and to a large extent Athenian. It is the excavations of recent years, like those on the Athenian Acropolis, which have made a scientific study of this branch of Greek archaeology possible. So long as the vases were known merely in museums, and the records of their discovery were either wanting entirely or were very defective, no progress could be made. Now archaeologists are able to work in the light, since many vases found actually on Greek soil, and in many different localities, have made the scientific classification of museum specimens possible.

Apart from the importance of vases in furnishing chronological clews to the excavator, and apart from the actual beauty of the best specimens, they are of uncommon interest as throwing light, not only upon the major art of painting among the Greeks, of which we know little, but also upon mythology. This comes from the fact that it was the habit of the vase decorators to choose the subjects that they represented from the rich store of Greek legend. The greater painters chose their subjects from the same source, and so it is to the vases that we must chiefly look in trying to form some conception of the work of these painters, which we know of otherwise only through literary tradition. Certain Attic vases, for example, dating from about the middle of the fifth century B.C., apparently throw much light upon the school of the great artist

Polygnotus. The relation of vase paintings to the Greek epic, the storehouse of legend, is analogous. Countless scenes taken from the popular mythology are represented on the vases. Sometimes they are quite in accord with literary tradition, again they reveal interesting variants from this tradition, and not infrequently a vase may show some form of a legend not otherwise known. The vase painter, however, did not work solely in the atmosphere of mythological tradition; he often chose subjects from everyday life. The school-room, the palaestra, the symposium, the boat-race, the ceremonies of marriage and death, and other everyday events furnish him material; there is in Boston an interesting *amphora* upon which a scene representing a woman being measured for a pair of shoes is painted. Taken all in all, there is perhaps no department of Greek archaeology which illustrates more plainly than vase painting does the light such study may throw upon a past civilization. The fact that it was a comparatively humble occupation, carried on by handicraftsmen, only makes it seem to draw us the nearer to the popular tradition and life.

I pass on now to the subject of inscriptions, a far-reaching topic, for the Greeks, and especially the Athenians, followed the practice of engraving records on stone to an extent that seems almost inconceivable. Treaties, law-codes, public decrees of all sorts, provisions for religious observance, temple records, records of Aesculapian cures, reports of commissions and of the expenditure of money, architectural specifications, dedications of offerings, records of literary and gymnastic contests, epitaphs—in short, almost every direction that human activity takes seems to find expression in inscriptions. This, of course, means that they should be considered as a department of archaeology only so far as their content bears upon matters which fall within the limits of this subject. I will choose, to

illustrate the archaeological character of some inscriptions, two examples which show the service they may render the student of Greek architecture. The first has to do with the temple on the Acropolis known as the Erechtheum, and under the following circumstances: In the year 409 B.C., this little temple, which has played so important a rôle in the architectural history of the western world, was apparently in an unfinished condition. Probably the long Peloponnesian war had put a stop to the work upon it. However that may be, the Athenian government decided to appoint a commission, which was required to make an exact report with reference to the condition of the building. This was done apparently very carefully, for we have the commission's report engraved on stone. It begins with these words, "We found the following parts unfinished," and then these parts are specified in a long list, and measurements are given. A year later the work had been done, and it was necessary to have an account of expenses, so another long inscription was prepared giving in detail the sums of money which had been paid out to the workmen for specific pieces of work. In both inscriptions there is of course incidental mention of many different portions of the temple. Now, about four years ago, the Greek authorities determined to carry out some repairs upon the ruins of the Erechtheum, so that at least their further decay might be arrested, and this work led to a very careful study of the scattered architectural fragments which could be assigned to the building. The time seemed propitious for a new publication of the temple, since all the existing studies of it are very inadequate, and the officers of our own School at Athens decided to undertake the work. Elaborate and very beautiful drawings have already been made by Mr. Gorham Stevens, of the office of McKim, Mead and White, while he was Fellow in Architecture at the School, and the careful archaeological study of the ruins is now going for-

ward. One of the important features of this study is the exact editing of these inscriptions which, in spite of the mutilated condition of some portions of them, have a great deal to tell of parts of the building now in ruins. Thus, in getting at the significance of the scattered architectural members, they are often of the highest importance, and never until now has it been possible to study them carefully in the light of a complete knowledge of the remains of the temple.

The second example of an important archaeological inscription is one from the year 342 B.C.; it concerns a naval arsenal that was to be built at the Piraeus. The inscription, which has hardly an illegible word in it, is headed, "Report (which here means specifications) of the stone storehouse for ship's tackle." There were apparently two commissioners, Euthydomus and Philo, of whom the latter was a well-known architect, and the storehouse now goes by the name of the "Arsenal of Philo." No vestige of this building remains, but so careful are the specifications, which include measurements, that it has been possible to make complete drawings of the building. Only a very few minor matters of detail are open to dispute. It would be possible to give many other examples of the important archaeological bearing of inscriptions, but these instances are perhaps sufficient; they are, at any rate, characteristic.

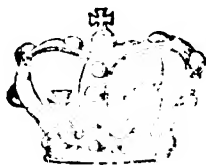
In citing the foregoing typical examples of work in Greek archaeology I trust I shall not be thought to have attempted even an outline sketch of the general subject. Had this been my purpose, I must have made mention of several other important branches of the study. Bronze work, for example, and work in gold and silver, shows the characteristics of other forms and periods of Greek art, and it is of the highest value, both for its intrinsic merit and because it affords the student much suggestive material for comparison with other things. The same is true

also of the art of gem cutting (glyptics) which extends from Mycenaean times down. And above all there is the great subject of coins (numismatics) which is really a specialty by itself. To the Greek archaeologist its importance can hardly be exaggerated; coins furnish the student of history important data with reference to the commercial and political relations between different communities; they frequently throw light on political changes; the student of religion and art finds in them many types in the representation of deities; they often afford information about portraiture, and the Greek coins of the Roman period not infrequently bear representations of famous statues, and other celebrated monuments of bygone times. Furthermore, the extraordinary beauty of the best specimens of Greek coinage raises them to a high artistic level which makes most modern attempts in this direction seem poor indeed.

Inadequate as this hasty survey of a great subject must be, I hope at least it may have suggested the high importance of archaeology in the study of the growth of human civilization. As the material from various regions and countries accumulates, it will of course throw much light upon the mutual relations of different peoples. Almost every year of late has brought some new suggestion of this kind, and Asia Minor, one of the great meeting-places of East and West, has been comparatively little explored. In many prehistoric fields, where the anthropologist and archaeologist work hand in hand, new views of the earlier conditions and relations of human life on the earth continually appear. Archaeology is still in its infancy, but the time seems surely coming when the comparative study of former races and civilizations may be based, far more than is possible to-day, on a sound knowledge of their handicraft and art.

HISTORY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
JANUARY 15, 1908**



HISTORY

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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published March, 1908.

HISTORY

HISTORY itself has a long history, extending, in Europe, from Herodotus and Thucydides to the most recent discussions in the current numbers of the "Historische Zeitschrift" and the "Moyen Âge." The changes which have from time to time overtaken it during two thousand years and more, have left indelible impressions which can alone explain the peculiar plight in which this particular branch of knowledge finds itself to-day, with all its inconsistencies, incongruities and vagueness of purpose. As we have listened to the clear and confident paeans of praise and thanksgiving which my predecessors in this course have raised, week after week, it has become clear to me that "blessed is the science without a history." Chemistry, Astronomy, Zoology, Physiology may have had a few errors of youth to live down, but they found themselves before their sensibilities had been permanently perverted by unfortunate associations. With History it is different. It seems never to lose any habits once formed. It adds new ambitions while retaining its old ones, discredited though they may be.

The story teller was probably the first to discover History; at any rate it has been unmistakably epic from the beginning. Its purpose has usually been to tell a tale rather than to contribute to a well organized body of sci-

tific truth. Indeed we shall not be far astray if we view History, as it has existed through the ages, even down to our own day, as a branch of general literature the object of which has been to present past events in an artistic manner, in order to gratify a natural curiosity in regard to the achievements and fate of conspicuous persons, the rise and decay of monarchies, and the signal commotions and disasters which have repeatedly afflicted humanity. Although the persistence of this primitive notion of history is so obvious as scarcely to demand illustration, it is interesting to note that as late as 1820, Daunou, a reputable French historian of his time, in a course of lectures upon the pursuit of history delivered at the Collège de France, declares that the master-pieces of epic poetry should claim the first attention of the would-be-historian, since it is the poets who have created the art of narrative. Next, from the modern novel, the student may learn, Daunou continues, "the method of giving an artistic pose to persons and events, of distributing details, of skilfully carrying on the thread of the narrative, of interrupting it, of resuming it, of sustaining the attention and provoking the curiosity of the reader."

After the poets and novels, the works of standard historians should be read with a view to surprising the secrets of their style—Herodotus, Thucydides, Xenophon, Polybius, and Plutarch; Caesar, Sallust, Livy, and Tacitus; and, among the moderns, Macchiavelli, Guicciardini, Giannone, Hume, Robertson, Gibbon, and Voltaire. When the foundations of an elegant literary style are firmly established the student may re-read the standard treatises with attention to the matter rather than the form, for, as even the judicious Daunou concedes, before writing history "it is evidently necessary to know it." Both Daunou's program and his list of names—unquestionably the most distinguished among historians throughout the centuries—tes-

tify to the strength of literary traditions among historical writers.

Yet a formal distinction at least has of course always been made between history and other branches of literature. This is emphasized by Polybius, writing in the second century before Christ. "Surely," he says, "an historian's object should be not to amaze his readers by a series of thrilling anecdotes, nor should he aim to produce speeches which *might* have been delivered, nor to study dramatic propriety in detail, like a writer of tragedy. On the contrary, his function is above all to record with fidelity what was actually said or done, no matter how commonplace it may be."

These warnings of Polybius were, however, commonly neglected by the ancient historian, whose object was to interest his readers in the great men and striking events of the past, or to prepare him for public life by describing and analyzing the policy of former statesmen and generals, or to teach him to bear with dignity the vicissitudes of fortune by recalling the calamities of others. It is clear that these ends of amusing, instructing or edifying were to be attained mainly by literary skill rather than by painful historical research.

To Thucydides, Polybius and Tacitus, history appeared to be purely human and secular. Its significance was confined to this world. To them any reflections upon the influence of the gods or upon providence would have seemed quite out of place. But with the advent of Christianity the past began to take on a religious and theological meaning. The greatest of all the church fathers, St. Augustine, appealed to history to substantiate and illustrate his theory of the two cities, one heavenly and one earthly; and his immortal work deeply affected the thought of Europe for centuries. Still more influential in determining the interpretation of history was a little manual of universal history

written, at Augustine's suggestion, by Orosius, one of his ardent disciples. This is directed against their pagan contemporaries, who maintained that their age was accursed above all others, owing to the desertion of the ancient gods.

The object of Orosius was to show that, on the contrary, a veritable carnival of death had preceded the appearance of Christianity. Accordingly, as he tells us, he brought together, in the compass of a single volume, all the examples he could find in the annals of the past "of the most signal horrors of war, pestilence and famine, of the fearful devastations of earthquakes and inundations, the destruction wrought by fiery eruptions, by lightning and hail, and the awful misery due to crime." History thus became for Orosius, and for his innumerable readers in succeeding centuries, the story of God's punishment of sin and the curse which man's original transgression had brought upon the whole earth.

But we need not expose ourselves to the hot and withering blasts of Orosius's rhetoric in order to realize the salient contrast between his conception of history's purpose and usefulness and that of the classical Greek and Roman writers. In the old days the danger had been that Clio would fall into the way of aping her sisters, poetry and the drama, and of borrowing their finery. Now, she permitted herself to be led away blindfolded by theology, which was for so long to be the potent rival of literature. The Greek historians and the greatest of the Roman, Tacitus, were forgotten in the Middle Ages; so the convenient pamphlet of Orosius served to distort Europe's vision of the past for a thousand years until Thucydides and Polybius came once more within its ken. But any influence that they exercised in reviving ancient ideals of historiography was far more than offset by the religious perturbations due to the Protestant Revolt.

Luther discovered that history could be appealed to to

support his attack upon what he called the "*Teufels Nest zu Rom*." And not long after his death a group of Protestants compiled a vast history of the church—"The Magdeburg Centuries," as it was called—in which they sought to prove the diabolical origin of the papacy and the Roman Catholic Church. Cardinal Baronius replied in twelve folio volumes, written, as he trusted, under the direct auspices of the Virgin Mary, in which he set forth "the calamities divinely sent for the punishment of those who have dared to oppose in their arrogance, or conspire against, the true church of God." For three centuries each party continued to suborn history in its own interest, and one must still, to-day, allow for religious bias in important fields of historical research. Yet in spite of all its bitterness and blindness, religious controversies have stimulated much scholarly investigation in modern times, and we should be much poorer if certain works of a distinctly partisan character had never been written,—for example, Raynaldus' continuation of Baronius and, in our own days, Janssen's "History of the German People," and Pastor's "History of the Popes."

To the authors of the "Magdeburg Centuries" and to Cardinal Baronius the great, obvious, determining historical forces were God and the devil. Our conception of God, as well as our ideas of history, have been changing, however, since the sixteenth century and it is rare now to find a historian who possesses the old confidence in his ability to penetrate God's counsels and trace his dispensations in detail. As for the devil few events can longer be ascribed to him with perfect assurance.

The reversion to Greek standards of historical composition represented by Macchiavelli and Guicciardini in the early sixteenth century became pronounced in the eighteenth. Gibbon, Voltaire, Hume, Robertson and others successfully re-secularized history and strove to give their

narratives of political events the ancient elegance of form. Moreover, since the middle of the eighteenth century, new interests other than the more primitive literary, political, military, moral and theological, have been developing. These have exercised a remarkable influence upon historical research, radically altering its spirit and aims and broadening its scope. To take a single example, Montesquieu's "Spirit of Laws"—first published in 1748—reviews the past with the purpose of establishing a purely scientific proposition, namely, the relativity of all human institutions, social, political, educational, economic, legal and military. The discussions attending the drafting of the first French constitution (1789–1791) served to provoke a study of constitutional history which has never since flagged.

In the nineteenth century people continued, as they always had done, to see their own particular interests reflected in the dim mirror of the past. One might know nothing of the modern varieties of historical interpretation and yet be confident that there would be one discoverable corresponding to each of the main currents of thought and endeavor. Now among the most unmistakable phenomena of the nineteenth century were the rise of the spirit of nationality, the struggle for constitutional government, the enthusiasm for natural science, the doctrine of evolution, the industrial revolution and the impetus which this has given to economic theory and the discussion of economic reform. History was ready to serve all the causes here enumerated, as well as some others of which there is no time to speak.

Early in the nineteenth century the cosmopolitan sentiments so conspicuous at the opening of the French Revolution began to give way to the spirit of nationality which was awaking in the various European states, especially Germany. This almost immediately showed itself in a

new and highly characteristic interpretation of history. While I make no pretensions to understanding Hegel I am going to repeat a few things he said in his lectures on the philosophy of history, first delivered in Berlin in the winter of 1822-1823, for many people thought they did understand him and were deeply affected by his teachings. As he looked back over the restless mutations of individuals and peoples, existing for a time and then vanishing, he was confident that he could trace the World-Spirit striving for consciousness and then for freedom, its essential nature. This Spirit assumes successive forms which it successively transcends. These forms appear in the peculiar national genius of historic peoples. The spirit of a particular people having strictly defined characteristics "erects itself," Hegel explains, "into an objective world that exists and persists in a particular form of religious worship, customs, constitution, and political laws,—in short, in the whole complex of its institutions and in the events and transactions that make up its history." The Persians, Hegel held, were the first world-historical people, for was it not in Persia that Spirit first began to attain an "unlimited immanence of subjectivity?" The Greek character was "individuality conditioned by beauty." "Subjective inwardness" was the general principle of the Roman world.

Ingenious as this may be, it would hardly have formed the basis of a new gospel of national freedom and deeply affected historical interpretation, had it not been for Hegel's extraordinary discovery that it was his own dear German nation in which it had pleased the *Weltgeist* to assume its highest form. "The German Spirit is the Spirit of the new world," Hegel proclaims; "its aim is the realization of absolute truth, as the unlimited self-determination of Freedom . . . The destiny of the German peoples is to be the bearers of the Christian principle." The supreme rôle assigned to his countrymen by Hegel filled them with justi-

fiable pride. And was not his assumption amply borne out by the glories of *Deutschthum* in the Middle Ages, which the Romanticists were singing; and, much more recently, by the successful expulsion of the French tyrant only a few years before? That all this should combine to give a distinct national and patriotic trend to historic research and writing was inevitable. The great collection of the sources for the German Middle Ages,—the “*Monumenta Germaniae Historica*”—which was to become a model for other nations, began to be issued in 1826 and for the first time the Germans became the leaders in the historical field as in so many others. Ranke, Dahn, Giesebrecht, Waitz, Droysen and dozens of others who began to devote themselves to German history, were all filled with a warm patriotism and enthusiasm very different from the cosmopolitan spirit of the preceding century. Throughout Europe history tended to become distinctly national, and an extraordinary impetus was given to the publication of vast collections of material. It is, however, hardly necessary to point out that national enthusiasm, even that of a German, has its dangers. It fostered some singular misapprehensions which Fustel de Coulanges and other more recent writers have rectified. Moreover we in America have allowed ourselves to be somewhat imposed upon by German erudition and have got into the habit of giving more attention to the Middle Ages and to German history than is really justified by their relative importance. To-day we surely have more to learn from France than Germany.

It was natural that this national spirit and the political and constitutional questions of the nineteenth century should serve to perpetuate the older interest in political history. This is the most ancient, most obvious and easiest kind of history, for the policy of kings, the laws they issued and the wars they fought have always been the matters which were likeliest to be recorded. Then the State is the

most imposing and important of man's social creations and many historians have felt that what was best worth knowing in the past could be directly or indirectly associated with its history. Ranke, Droysen, Maurenbrecher, Freeman and many others deemed political history to be history *par excellence*. In the historical seminar rooms of Johns Hopkins University Freeman's words, "History is past politics," are inscribed over the entrance.

During the past thirty years a rather bitter conflict has, however, been waged in Germany between the representatives of the political conception of history and those who clamored for the recognition of *Kulturgeschichte* as entitled to an equal if not distinctly superior rank. Now *Kulturgeschichte* includes such matters as have hitherto been generally passed over in the routine of historical writing and instruction. The fundamental and enduring intellectual, educational, artistic, and even economic conditions have been neglected,—so the advocates of *Kulturgeschichte* complain,—in favor of fleeting political and military events, court intrigues and futile diplomatic negotiations. While the aims of the *Kulturhistoriker* are necessarily rather vague at first, and his operations have not the precision of the scholarship represented in the narrower, traditional school, the justice of his contentions is too obvious to be questioned. We have an inalienable right to study anything we please in the past. If the appearance and effects of Peter Lombard's "Sentences" appeals to us rather than the contemporaneous doings of the emperor Lothaire, it is not difficult to make out a case in favor of the theologian's importance. And surely the development of the German language in the eleventh and twelfth century is as important as the struggle between Welf and Hohenstaufen.

We have now reviewed the chief motives which appear to have influenced the greater number of historical writers

from Thucydides to Macaulay and Ranke. They all agreed in examining more or less conscientiously and critically the records of past events and conditions with a view of amusing, edifying or comforting the reader. But none of the interests of which I have so far spoken can be regarded as scientific. To scan the past with the hope of discovering recipes for the making of statesmen and warriors, of discrediting the pagan gods, of showing that Catholic or Protestant is right, of exhibiting the stages of self-realization of the *Weltgeist*, or demonstrating that Liberty emerged from the forests of Germany never to return thither,—none of these motives are scientific although they may go hand in hand with much sound scholarship. But by the middle of the nineteenth century the muse of history, *semper mutabile*, began to fall under the potent spell of natural science. She was no longer satisfied to celebrate the deeds of heroes and nations with the lyre and shrill flute on the breeze-swept slopes of Helicon; she no longer durst attempt to vindicate the ways of God to man. She had already come to recognize that she was ill-prepared for her undertakings and had begun to spend her mornings in the library, collating manuscripts and making out lists of variant readings. She aspired to do even more and began to talk of raising her chaotic mass of information to the rank of a science.

But history, in order to become scientific, had first to become historical. Singularly enough what we now regard as the strictly historical interest was almost missed by historians before the nineteenth century. They narrated such past events as they believed would interest the reader; they commented on these with a view of instructing him, fortifying his virtue or patriotism or staying his faith in God. In a way it was not so very important whether they took pains to verify their facts or not. Indeed, the exact truth, when we are lucky enough to get a glimpse of

it, is rarely so picturesque or so edifying as what might have been. Still they did take some pains to find out how things really were—*wie es eigentlich gewesen*, to use Ranke's famous dictum. To this extent they were scientific, although their motives were mainly literary, moral or religious. They did not, however, in general try to determine how things had come about—*wie es eigentlich geworden*. History thus remained for two or three thousand years a record of past events, and this definition satisfies the thoughtless still. But it is one thing to describe what once was; it is quite another to attempt to determine how it came about.

There is not time on this occasion to attempt to trace the causes and gradual development of this genetic interest. The main reason for its present strength lies probably in our modern lively consciousness of the reality and inevitability of change, examples of which are continually forcing themselves upon our attention. The Greek historians had little or no background for their narratives. It is amazing to note the contemptuous manner in which Thucydides rejects all accounts of even the immediately preceding generation, as mere uncertain traditions. Polybius set himself the task of tracing the gradual extension of the Roman dominion, but there is no indication that he had any clear idea of the continuity of history. In the Middle Ages there was undoubtedly a notion that the earth was the scene of a divine drama which was to culminate in the definitive separation of the wheat from the tares; but this supernatural unity of history was not scientific but theological. In earthly matters the mediaeval man could hardly have understood the meaning of the word, anachronism; the painters of the Renaissance did not hesitate to place a crucifix over the manger of the divine infant and there was nothing incongruous in this to their contemporaries.

Not until the eighteenth century did the possibility of

indefinite human progress become the exhilarating doctrine of reformers, a class which had previously attacked existing abuses in the name of the "good old times." No discovery could be more momentous and fundamental than that reform should seek its sanction in the future, not in the past; in advance, not in reaction. It became clearer and clearer that the world *did* change, and by the middle of the nineteenth century the continuity of history began to be accepted by the more thoughtful students of the past and began to affect as never before their motives and methods of research.

The doctrine of the continuity of history is based upon the observed fact that every human institution, every generally accepted idea, every important invention, is but the summation of long lines of progress, reaching back as far as we have the patience or means to follow them. The jury, the drama, the gatling gun, the papacy, the letter "s," the doctrine of transubstantiation, each owes its present form to antecedents which can be scientifically traced. But no human interest is isolated from innumerable concurrent interests and conditioning circumstances. This brings us to the broader conception of the continuity of change which is attributable to the complexity of men's affairs. A somewhat abrupt change may take place in some single institution or habit but a sudden general change is almost inconceivable. An individual may, through some modification of his environment, through bereavement of malignant disease, be quickly and fundamentally metamorphosed, but even such cases are rare. If all the habits and interests of the individual are considered it will be found that only in the most exceptional cases are any great number of these altered in the twinkling of an eye. And society is infinitely more conservative than the individual, for reasons which need not be reviewed here. Now—and this cannot be too strongly emphasized—the continuity of history is a sci-

entific truth, the attempt to trace the slow process of change is a scientific problem, and one of the most fascinating in its nature. It is the discovery and application of this law which has served to differentiate history from literature and morals and raise it in one sense to the dignity of a science.

Earlier lectures in this course have made plain the tremendous importance of the developmental treatment in nearly all the branches of natural science. It is equally new and equally revolutionary in its application to humanity. The older historians had little inclination to describe familiar conditions and the common routine of everyday life. It was the startling and exceptional that caught their attention and which they found recorded in the sources upon which they depended. They were like a geologist who should deal only with earthquakes and volcanoes, or better still, a zoologist who should have no use for any thing smaller than an elephant or less picturesque in its habits than a phoenix or a basilisk. An appreciation of the overwhelming significance of the small, the common and the obscure establishes the brotherhood of all scientific workers whatever their fields of activity.

History has so long been concealed behind a mask which has served either to enhance the charm of her homely features beyond all recognition, or to render her familiar and commonplace form monstrous and repulsive, that it is little wonder that historians only slowly adjust themselves to the new point of view. The first and greatest contribution to the scientific study of history came from an unexpected source and was again a clear reflection of the dominant practical exigencies of the time. Perhaps Buckle was right when he declared that the historians have on the whole been inferior in point of intellect to thinkers in other fields. At any rate it was a philosopher, economist and reformer, not a professional student of history, who suggested a wholly

new and wonderful series of questions which the historian might properly ask about the past, and moreover furnished him with a scientific explanation of many matters hitherto ill-understood. I mean Karl Marx.

In a singular pamphlet called "The Holy Family," written in 1845, Marx denounced those who discover the birthplace of history in the shifting clouds of heaven instead of in the hard, daily work on earth. He maintained that the only sound and ever valid general explanation of the past was economic. The history of society depends, he held, upon the methods by which its members produce their means of support and exchange the products of industry among themselves. The methods of production and transportation determine the methods of exchange, the distribution of products, the division of society into classes, the relations of the several classes, the existence of the State, the character of its laws, and of all that it means for mankind. We are not concerned here with the complicated genesis of this idea, nor with the precise degree of originality to be attributed to Marx's presentation of it. Nor is there time to explain the manner in which Marx's theory was misused by himself and his followers. Few, if any, historians would agree that everything can be explained economically, as many of the socialists and some economists of good standing would have us believe. But in the sobered and chastened form in which most economists now receive the doctrine, it serves to explain far more of the phenomena of the past than any other single explanation ever offered. It is the economist who has opened up the most fruitful new fields of research by emphasizing the importance of the enduring but often inconspicuous factors which almost entirely escaped historians before the middle of the nineteenth century. I am inclined to think that Jaurès, one of the leaders of the French socialists, has written what is, on the

whole, the most illuminating history of the French Revolution. Moreover he has induced the French government to appoint a commission to investigate and edit the chief sources for the economic history of that great movement. No one can glance at the volumes that have recently been appearing in that series without realizing the fundamental character of the material they contain as compared with similar series issued under the influence of the older canons of importance.

It was inevitable that attempts would be made to reduce history to a science by reconstructing it upon the lines suggested by the natural sciences. The most celebrated instance of this is Buckle's uncompleted "History of Civilization," the first volume of which appeared in 1857. It seemed to him that while the historical material which had been collected, when looked at in the aggregate, had "a rich and imposing appearance," the real problem of the historian had hardly been suspected, let alone solved. "For all the higher purposes of human thought," he declares, "history is still miserably deficient, and presents that confused and anarchical appearance natural to a subject of which the laws are unknown and even the foundations unsettled." He accordingly hoped, he tells us, to "accomplish for the history of man something equivalent, or at all events analogous, to what has been effected by other inquirers for the different branches of natural science. In regard to nature, events apparently the most irregular and capricious have been explained, and have been shown to be in accordance with certain fixed and universal laws. This has been done because men of ability, and, above all, men of patient, untiring thought, have studied natural events with the view of discovering their regularity; and if human events were subjected to a similar treatment, we have every right to expect similar results." Buckle proposed to discover the laws, physical and mental, which govern the workings of mankind and then trace their operations in the general de-

velopment of civilization. Unlike Marx, Buckle believed that physical laws tended to become well-nigh inoperative in so highly developed a civilization as that of Europe and that, consequently, the moral and intellectual laws should constitute the main object of the historian's search.

Fifty years have elapsed since Buckle's book appeared, and I know of no historian who would venture to maintain that we had made any considerable advance toward the goal he set for himself. A systematic prosecution of the various branches of social science, especially political economy and anthropology, perhaps of psychology,—if that be a social science—has served to explain some things, but history must always remain, from the standpoint of the astronomer, physicist or chemist, a highly inexact and fragmentary body of knowledge. This is due mainly to the fact that it concerns itself with man, his devious ways and wandering desires, which it seems hopeless at present to bring within the compass of clearly defined laws of any kind. Then our historical knowledge must forever rest upon scattered and highly precarious data, the truth of which we have no means of testing. This melancholy fact is not so well known as it should be, for in writing for the public even conscientious scholars have hitherto found themselves suppressing their doubts and uncertainties until they were scarcely aware that they ever had them; concealing their pitiful ignorance and yielding to the temptation to ignore yawning gulfs at whose brink History must halt even though Literature can bridge them with ease. I should like to dwell for a moment on this painful theme of our ineluctable ignorance over which Literature has been wont to throw a kindly veil. For it is to a considerable extent an exaggerated notion of the extent of our knowledge that has encouraged the reckless ventures of those who have dreamed of reducing history to an exact science.

Fifty years ago it was generally believed that we knew

something about man from the very first. Of his abrupt appearance on the freshly created earth and his early conduct, there appeared to be a brief but exceptionally authoritative account. Now we are beginning to recognize the immense antiquity of man. There are paleolithic implements which there is some reason for supposing may have been made a hundred and fifty thousand years ago; the eolithic remains recently discovered may perhaps antedate the paleolithic by an equally long period. Mere guesses and impressions, of course, this assignment of millenniums, which appear to have been preceded by some hundreds of thousands of years during which an animal was developing with "a relatively enormous brain case, a skilful hand and an inveterate tendency to throw stones, flourish sticks" and, in general, as Ray Lankester expresses it, "to defeat aggression and satisfy his natural appetites by the use of his wits rather than by strength alone." There may still be historians who would argue that all this has nothing to do with history;—that it is "prehistoric." But "prehistoric" is a word that must go the way of "preadamite," which we used to hear. They both indicate a suspicion that we are in some way gaining illicit information about what happened before the foot lights were turned on and the curtain rose on the great human drama. Of the so-called "prehistoric" period we of course know as yet very little indeed, but the bare fact that there was such a period constitutes in itself the most momentous of historical discoveries. The earliest, somewhat abundant, traces of mankind can hardly be placed earlier than six thousand years ago. They indicate, however, a very elaborate and advanced civilization and it is quite gratuitous to assume that they represent the first occasions on which man rose to such a stage of culture. Even if they do, the wonderful tale of how the conditions of which we find hints in Babylonia, Egypt and Crete came about is lost.

Let us suppose that there has been something worth saying about the deeds and progress of mankind during the past three hundred thousand years at least; let us suppose that we were fortunate enough to have the merest outline of such changes as have overtaken our race during that period, and that a single page were devoted to each thousand years. Of the three hundred pages of our little manual the closing six or seven only would be allotted to the whole period for which records, in the ordinary sense of the word, exist, even in the scantiest and most fragmentary form. Or, to take another illustration, let us imagine history under the semblance of a vast lake into whose rather turbid depths we eagerly peer. We have reason to think it at least twenty-five feet deep, perhaps fifty or a hundred; we detect the very scantiest remains of life, *rara et disjecta*, four or five feet beneath the surface, six or seven inches down these are abundant, but at that depth we detect, so to speak, no movements of animate things, which are scarcely perceptible below three or four inches. If we are frank with ourselves we shall realize that we can have no clear and adequate notion of anything happening more than an inch,—indeed, scarce more than half an inch below the surface.

From this point of view the historian's gaze, instead of sweeping back into remote ages when the earth was young, seems now to be confined to his own epoch, Rameses the Great, Tiglath-Pileser and Solomon appear practically coeval with Caesar, Constantine, Charlemagne, St. Louis, Charles V, and Victoria; Bacon, Newton, and Darwin are but the younger contemporaries of Thales, Plato, and Aristotle. Let those pause who attempt to determine the laws of human progress or decay. It is like trying to determine by observing the conduct of a man of forty for a month, whether he be developing or not. Anything approaching a record of events does not reach back for more than three

thousand years and even this remains shockingly imperfect and unreliable for more than two millennia. We have a few, often highly fragmentary, literary histories covering Greek and Roman times, also a good many inscriptions and some important archeological remains; but these leave us in the dark upon many vital matters. The sources for the Roman Empire are so very bad that Mommsen refused to attempt to write its history. Only in the twelfth and thirteenth centuries do the mediaeval annals and chronicles begin to be supplemented by miscellaneous documents which bring us more directly into contact with the life of the time.

Yet the reader of history must often get the impression that the sources of our knowledge are, so to speak, of a uniform volume and depth, at least for the last two or three thousand years. When he beholds a voluminous account of the early Church, or of the Roman Empire, or observes Dahn's or Hodgkin's many stately volumes on the Barbarian invasions, he is to be pardoned for assuming that the writers have spent years in painfully condensing and giving literary form to the abundant material which they have turned up in the course of their prolonged researches. Too few suspect that it has been the business of the historian in the past not to condense but on the contrary skilfully to inflate his thin film of knowledge until the bubble should reach such proportions that its bright hues would attract the attention and elicit the admiration of even the most careless observer. One volume of Hodgkin's rather old fashioned "Italy and her Invaders," had the scanty material been judiciously compressed, might have held all that we can be said to even half-know about the matters to which the author has seen fit to devote eight volumes.

But pray do not jump to the conclusion that the historical writer is a sinner above all men. In the first place, it should never be forgotten that he is by long tradition a

man of letters, and that that is not, after all, such a bad thing to be. In the second place he experiences the same strong temptation that everyone else does to accept, at their face value, the plausible statements which he finds, unless they conflict with other accounts of the same events or appear to be inherently improbable. Lastly he is, like his fellow primates, the victim of what Nietzsche has called "dream logic." I am sure that we do not reckon constantly enough with this inveterate tendency of even a highly cultivated mind instinctively to elaborate and amplify mere hints and suggestions into complete and vivid pictures.

To take an illustration of Nietzsche's, the vague feeling, as we lie in bed, that the soles of our feet are free from the usual pressure to which we are accustomed in our waking hours demands an explanation. Our dream explanation is that we must be flying. Not satisfied to leave its work half done, dream logic fabricates a room or landscape in which we make our aerial experiments. Moreover just as we are going to sleep or awaking we can often actually observe how a flash of light, such as sometimes appears on the retina of our closed eyes, will be involuntarily interpreted as a vision of some human figure or other object, clear as a stereopticon slide. Now anyone can demonstrate to himself that neither dream logic nor the "mind's-eye faculty," as it has been called, desert us when we are awake. Indeed they may well be, as Nietzsche suspects, a portion of the inheritance bequeathed to us, along with some other inconveniences, by our brutish forebears. At any rate they are forms of aberration against which the historian, with his literary traditions, needs specially to be on his guard. There are rumors that even the student of natural science sometimes keeps his mind's eye too wide open, but he is by no means so likely as the historian to be misled by dream logic. This is not to be ascribed necessarily to the superior self-restraint of the scientist but rather to the greater sim-

plicity of his task and the palpableness of much of his knowledge. The historian can almost never have any direct personal experience of the phenomena with which he deals. He only knows the facts of the past by the traces they have left. Now these traces are usually only the reports of someone who commonly did not himself have any direct experience of the facts and who did not even take the trouble to tell us where he got his alleged information. This is true of almost all the ancient and mediaeval historians and annalists. So it comes about that "the immense majority of the sources of information which furnish the historian with starting points for his reasoning are nothing else than traces of psychological operations" rather than direct traces of the facts.

To take a single example from among thousands which might be cited, Gibbon tells us that after the death of Alaric in 410 "The ferocious character of the Barbarians was displayed in the funeral of the hero, whose valor and fortune they celebrated with mournful applause. By the labor of a captive multitude they forcibly diverted the course of the Busentinus, a small river that washes the walls of Consentia. The royal sepulchre, adorned with the splendid spoils and trophies of Rome, was constructed in the vacant bed; the waters were then restored to their natural channel, and the secret spot, where the remains of Alaric had been deposited, was for ever concealed by the inhuman massacre of the prisoners who had been employed to execute the work." The basis of this account is the illiterate "History of the Goths" written by an ignorant person, Jordanes, about a hundred and forty years after the occurrence of the supposed events. We know that Jordanes copied freely from a work of his better instructed contemporary, Cassiodorus, which has been lost. This is absolutely all that we know about the sources of our information.

Shall we believe this story which has found its way into so many of our textbooks? Gibbon did not witness the burial of Alaric nor did Jordanes, upon whose tale he greatly improves, nor did Cassiodorus who was not born until some eighty years after the death of the Gothic king. We can control the "psychological operation" represented in Gibbon's text, for he says he got the tale from Jordanes, but aside from our suspicion that Jordanes took the story from the lost book by Cassiodorus we have no means of controlling the various psychological operations which separate the tale as we have it from the real circumstances. We have other reasons than Jordanes' authority for supposing that Alaric is dead, but as for the circumstances of his burial we can only say they may have been as described, but we have only the slightest reason for supposing that they were. The scope for dream logic and the mind's-eye faculty as well as for mistakes and misapprehensions of all kinds is in such cases infinitely greater than when one deals with his own impressions, which can be intensified and corrected by repeated observations and clarified by experiment. As Langlois remarks, the historian is like a chemist who should be forced to rely for his knowledge of a series of experiments upon what his laboratory boy told him.

It should now have become clear that history can never become a science in the sense that physics, chemistry, physiology, or even anthropology, is a science. The complexity of the phenomena is appalling and we have no way of artificially analyzing and of experimenting with our facts. We know absolutely nothing of any occurrences in the history of mankind during thousands of years and it is only since the invention of printing that our sources have become in any sense abundant. Historical students have moreover become keenly aware of the "psychological operations" which separate them from the objective facts of the

past. They know that all narrative sources, upon which former historians so naïvely relied, are open to the gravest suspicion and that even the documents and inscriptions which they prize more highly are nevertheless liable to grave misinterpretation.

But if there is no hope that history can become a science in the sense in which the term is usually accepted, why should it not resign itself to remaining, as it always has been essentially, a branch of literature? Since all departments of knowledge have now become historical, what need is there of history in general? If politics, war, art, law, religion, science, literature, be dealt with genetically, will not history tend inevitably to disintegrate into its organic elements? Professor Seeley of the University of Cambridge believed that it would. Twenty years ago he declared that history was after all but the name of "a residuum which has been left when one group of facts after another has been taken possession of by some science; that residuum which now exists must go the way of the rest, and that time is not very distant when a science will take possession of the facts which are still the undisputed property of the historian."

Now the last question I have to discuss is whether history, after gaining the whole world, is destined to lose her own soul. Let us assume that historical specialization has done its perfect work, that every distinct phase of man's past, every institution, sentiment, conception, discovery, achievement or defeat which is recorded has found its place in the historical treatment of the particular branch of research to which it has been assigned according to the prevailing classification of the sciences. This process of specialization would serve to rectify history in a thousand ways, and to broaden and deepen its operations, but, instead, of destroying it, it would rather tend, on the contrary, to demonstrate with perfect clearness its absolute indispensability. Human affairs and human change do not lend

themselves to an exhaustive treatment through a series of monographs upon the ecclesiastical or military organization of particular societies, their legal procedure, agrarian system, their art, domestic habits or views on higher education. Many vital matters would prove highly recalcitrant when one attempted to force them into a neat scientific cubby-hole. Physical, moral and intellectual phenomena are mysteriously interacting in that process of life and change which it falls to the historian to study and describe.

Man is far more than the sum of his scientifically classifiable operations. Water is composed of hydrogen and oxygen, but it is not like either of them. Nothing could be more artificial than the scientific separation of man's religious, aesthetic, economic, political, intellectual and bellicose properties. These may be studied, each by itself, with advantage, but specialization would lead to the most absurd results if there were not someone to study the process as a whole; and that someone is the historian. Imagine the devotees of the various social sciences each engaged in describing his particular interest in the Crusades or the Protestant Revolt or the French Revolution. When they had finished would not the historian have to retell the story in his way, utilizing all that they had accomplished, including what they had all omitted, and rectifying the errors into which each of the specialists had fallen on account of his ignorance of the general situation? The historian will moreover engage in his own kind of specialization. He no longer confines himself to cross sections of the past but traces ideas and institutions morphogenetically—if I may be permitted to borrow that polite term.

As for his ignorance, which I have so frankly revealed, he now recognizes that in all humility, and is making every effort to remedy it by the application of highly scientific methods. He shares it moreover with the representatives of all the social sciences who attempt to carry their work back

into the past. The historian will become more and more interested, I believe, in explaining the immediate present and fortunately his sources for the immediately preceding two or three centuries are infinitely more abundant and satisfactory than for the whole earlier history of the world. He is criticizing and indexing his sources and rendering them available to an extent which would astonish a layman unfamiliar with the tremendous amount that has been accomplished in this way during the ~~past fifty years~~. Every year adds to our resources here in New York City material that was formerly out of reach of even the most assiduous European scholar. Every year witnesses important additions to our knowledge of our own national history.

WE have now seethed the kid in its mother's milk. We have explained History by means of History. The historian is from a narrow scientific point of view a little higher than a man of letters and a good deal lower than an astronomer or biologist. He need not however repudiate his literary associations, for they are eminently respectable, but he will aspire hereafter to find out not only exactly how things have been but how they have come about. He will remain the critic and guide of the social sciences whose results he must synthesize and test by the actual life of mankind as it appears in the past. His task is so grand and so comprehensive that it will doubtless gradually absorb his whole energies and wean him in time from literature, for no poet or dramatist ever set before himself a nobler or a more inspiring ideal, or one making more demands upon the imagination and resources of expression, than the destiny which is becoming clearer and clearer to the historian.

ECONOMICS

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
JANUARY 22, 1908**



ECONOMICS

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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published February, 1908.

ECONOMICS

WHEN Professor Crampton finished his lecture on Zoology a few weeks ago and it was understood that the social sciences would next be taken up, some one in this audience said: "Now they will begin to talk about what they don't know." Whether my immediate predecessor overheard this remark, I cannot say. If he did he replied to it in a way that it would be vain to try to imitate—by showing that to hear about what is not known may be quite as instructive and even more entertaining than to hear about what is. With Professor Robinson's revelations in regard to the deficiencies of History still ringing in my ears, like a call to the confessional, I have no desire to make extravagant claims for *my* subject. We economists do still talk about what we don't know. We have reached a stage, however, when with clear utilitarian purpose we talk more and more about what we should like to know, a good deal about what we hope to know, and a little, a saving little about what we think we do know.

Economics, or Political Economy, is the social science which treats of all of the interests and activities connected with the mundane task of earning a living. It is the social science of business. This definition, accepted in substance, if not in form, by all present-day economists, was reached only after prolonged discussion. Passing over the first beginnings of economic speculation in oriental and classical literature, we find that in Europe in the Middle Ages the subject was cultivated as a branch, not of political science,

but of ethics. The questions most actively discussed by mediaeval thinkers turned not on the explanation of economic phenomena, but on their justification. Thus the inquiry was not as to why the rate of interest charged at the time was high, but as to whether there was moral justification for charging any interest.

As the mediaeval restraints on trade and industry were relaxed the discussion of economic phenomena passed from theologians to merchants and government officials. Taxation, the control of monetary systems, and the regulation of commerce were the principal matters considered in the fifteenth, sixteenth, and seventeenth centuries and some progress was made toward an understanding of these subjects.

In the latter part of this period economic questions began to be approached from the standpoint of the whole people rather than from that of kings or the ruling classes; a change that was at first justified more on the ground that an impoverished people means an impoverished sovereign, — *pauvres paysans, pauvre Royaume, pauvre Royaume, pauvre Roi*, as Vauban writing in 1717 expressed it— than because the welfare of the people was squarely recognized as of primary importance. When Adam Smith published his "Wealth of Nations" in 1776 this broader conception was firmly established, but Adam Smith himself still thought of Political Economy as the art of making nations wealthy and prosperous, rather than as the science of explaining wealth and prosperity.

It was not until the first quarter of the nineteenth century, when Political Economy had been dignified in England by recognition as a college discipline, that the subject began to be defined and treated as a science. The materials for the new science had all or nearly all been brought together earlier, but it required Ricardo's combination of business experience and talent for abstract

reasoning, James Mill's passion for clear and logical exposition, and the leisure for academic refinements of analysis enjoyed by Malthus and Senior to bring the different parts of the subject together into what is now designated as the classical or orthodox system. That system has influenced so profoundly the course of economic thought even down to the present day that a brief exposition of its leading principles must be given.

To understand the classical system it is necessary to study it in connection with the industrial situation in England at the time that it was formulated. Though exhausted and impoverished by the Napoleonic wars, that country was throbbing with the great economic changes brought about by the inventions and discoveries of the last half of the eighteenth century. Manufacturing industries were growing at an unprecedented rate. Population was beginning to be concentrated in Yorkshire and Lancashire where the coal and water power called for by the new processes were to be had abundantly. The capitalist-employer was coming forward as the directing spirit in the new industries and the opposition between his interests and those of the landholding aristocracy, which still dominated Parliament, was beginning to stand out clearly. Finally, in consequence of the war and of the partial suspension of the country's foreign commerce, high prices prevailed for agricultural products, and not only did the landlords of the country enjoy unusually high rents from their estates, but a considerable extension of agriculture to lands that had before been deemed unfit for cultivation was observable. The interest of landlords in a continuance of these high prices was as clear as was the interest of other classes in bringing about their reduction.

It was on the background formed by these industrial conditions that Ricardo and his disciples, combining subtle reasoning with heroic abstraction from the complex facts

of life, sketched the closely related theories which for a time seemed to raise economics to the position of an exact science.

The factors in the production of wealth which the classical economists distinguished—land, labor and capital—corresponded to the three great social classes of the period, landlords, wage-earners, and capitalist-employers. Each of these factors was supposed to receive a share in the products of industry, the familiar rent, wages and profits. To explain these shares was, as Ricardo declared in his epoch-making treatise, “the principal problem in Political Economy.”

Rent, the share of the landowner, was explained very simply as a differential return due to the superior fertility or the superior location of the better pieces of land as compared with the poorer.

The explanation of wages was more complex, since two different and supplementary theories, one, applying to short, the other to long periods, were advanced. Over short periods wages were believed to depend upon the proportion between the accumulated fund of capital and the number of wage-earners. This was the famous wages-fund theory which was still confidently held by John Stuart Mill when he wrote his “Political Economy” in 1848. As stated by Mill, the theory is that “wages depend not only upon the relative amount of capital and population, but cannot be affected by anything else. Wages (meaning, of course, the general rate) cannot rise but by an increase of the aggregate funds employed in hiring laborers, or in a diminution of the number of competitors for hire; nor fall, except either by a diminution of the funds devoted to paying labor, or by an increase of the number of laborers to be paid.” This theory of the rigid dependence of wages upon capital, with the practical conclusion deduced from it that neither labor organizations nor factory acts could do

anything to improve materially the lot of wage-earners, served more than any other part of the classical system to earn for economics the title of "dismal science." That this theory, at one time universally accepted, is now universally condemned, may be cited as a solemn warning against over-confident generalization touching phenomena too complex to be explained by any simple formula.

To account for the course of wages over long periods the classical economists relied on the Malthusian doctrine of population. Population, they thought, is constantly pressing on the food supply. Any increase in the wages-fund tends to encourage an increase of population. In the long run wages tend to correspond with the standard of living of the wage-earning masses, the standard of subsistence, that is, which wage-earners insist on having in the sense that when wages fall below this level the growth of population will be checked until they are brought again up to it. Malthus at first thought that this minimum standard was no more than the subsistence absolutely necessary to enable the wage-earner to rear a family, and that misery and vice were the divinely ordained means of maintaining the necessary balance between population and the food supply. Further thought convinced him and the other classical writers that the standard of living is elastic and that wages determined by what later came to be called their "iron law" were not necessarily low wages. They continued, however, to think of wages in terms of food and to make little real allowance for the development of higher wants on the part of the masses.

Ricardo's explanation of profits, the third and last share, was the least satisfactory part of his "Political Economy." Instead of attacking the problem of the reason for profits directly, he had recourse to the method of difference for his explanation. Having asserted that all wealth annually produced is divided into three parts, and having explained

how the parts called rent and wages are determined, it seemed to him sufficient to declare that whatever was left over must constitute profits. It remained for Senior to attempt to explain the why of profits on independent grounds and he did this by formulating clearly the so-called abstinence theory, hints of which are to be found in the discussions of earlier writers. According to this theory the abstinence of the capitalist bears the same relation to profits as does the effort of the laborer to wages. Both are elements in the cost of production, and both must be recognized as ultimate factors in the determination of economic relations.

In the completed form to which it was brought by the work of Senior, the classical system had at least the merit of simplicity. The production and distribution of wealth seemed to be completely explained by half a dozen clear-cut propositions. From them seemed to follow by inexorable logic the principle that governmental interference with industrial relations must prove futile, even when not positively harmful. And so persuaded were the classical writers of the correctness of their doctrines that during the fifty years from 1820 to 1870 most of their attention was devoted to the task of winning disciples.

Already in 1821, James Mill brought out an "Elements of Political Economy," based on lectures first delivered *in camera* to John Stuart when in his twelfth year. About the same time a more ambitious effort to popularize economics was made by a Mrs. Marcet, the author of a successful "Conversations on Chemistry." Her "Conversations on Political Economy,"—a treatise in which a "Mrs. B." gravely expounds all the mysteries of the classical system in reply to queries propounded by an ingenuous young maiden, Caroline,—was received with approval by the leading economists of the day. Even J. R. McCulloch, the narrowest, most dogmatic and most prolific of the

classical writers, condescended to say that "the little work, though puerile in its form and from a female pen, is not wanting in manly excellence."

But perhaps the clearest proof of the confidence with which the teachings of Ricardo were accepted is the part which our own broadly cultured Professor McVickar played in this effort to popularize economics. In 1885 he was moved to bring out a "First Lessons in Political Economy for the Use of Primary and Common Schools," and to introduce the work with the following significant sentences:

"The first principles of Political Economy are truisms which a child may understand, and which children should therefore be taught. In the last century they were among the speculations of the learned; they have now become the heritage of the nursery; and the only difficulty in teaching them in after life arises from a suspicion excited by their very simplicity."

To the modern reader another possible explanation of the "suspicion" to which Professor McVickar alludes suggests itself when he discovers that among the "truisms" which had become the "heritage of the nursery" are the labor theory of value and the *laissez-faire* theory of government.

Much more fruitful than these attempts to popularize economics were the applications that were made of the classical theories to the economic and political problems of the day. For, however inadequate these theories may seem as a basis for solving the world problems of the twentieth century, it cannot be denied that they supplied a veritable arsenal of arguments for attacking the problems which confronted England during the period of their greatest influence. In fact, the inadequacy of the classical theories—if we except the wages-fund theory, the most serious, not to say vicious error of the older writers—came from their being only half-true rather than untrue. For the most

part they have been supplemented rather than superseded by the theories formulated since 1870. Among the practical reforms in England which should in justice be credited to the classical economists and their disciples were the establishment of the gold standard, the reform of Parliament, the reform of the poor law, the abolition of slavery and the repeal of the corn laws. It was not until these reforms were accomplished that any serious effort was made to re-examine the accepted theories and adapt them to changing industrial conditions.

The arguments which served at length to discredit the theories of the classical system were advanced by at least five different types of thinkers. First, there were the moralists who attacked the system on the ground that the industrial society to which its theories applied stood self-condemned. They ridiculed economics as "the dismal science" and insisted that the "economic man" of whom the economists prated existed only in the imaginations of these "closet philosophers." Not a little encouragement to this line of criticism came from the economists themselves. Thus, John Stuart Mill broke so completely with the principles that he had himself expounded that before his death he became an avowed socialist. Even Cairnes, who made an effort as late as 1874 to rehabilitate the classical theories, showed so little enthusiasm for his task that he declares that co-operation "offers the sole escape from a hopeless situation." With such damaging admissions coming from the leaders it was not surprising that there was dissatisfaction in the ranks.

The second group of critics were the socialists, led by Karl Marx. They professed to accept the teachings of Ricardo and asked only that his theories be followed to their logical conclusion. For them this was summed up in the proposition that all incomes except wages are the result of legalized robbery.

More important was the third line of attack, the accumulation of facts both past and present by disciples of the German Historical School. These showed not only, that the premises which the economists advanced as universally true applied only to a few countries, and to them only at particular periods of their historical development, but also that the conclusions which the economists deduced from these premises failed to correspond with experience.

The fourth influence was the progress of biological studies and the growing appreciation of the importance of change in connection with all forms of organic life. From thinking of human nature and social institutions as relatively fixed, all students of social phenomena were led to think of them as undergoing a gradual evolution. This new conception was obviously inconsistent with the hard and fast principles of classical economics.

Finally and most important of all was the more searching examination to which the economists subjected their own theories. Thornton and others attacked the wages-fund theory and succeeded in securing a formal recantation from John Stuart Mill, upon whose authority much of the later day vogue of the theory had depended. Menger in Austria and Jevons in England showed the inadequacy of the cost-of-production theory of value and proposed in its place the marginal utility theory, now very generally accepted. Our own Walker and others showed the necessity of recognizing other shares in distribution than the traditional rent, wages and profits, and thus prepared the way for a more accurate analysis. Similarly, the Malthusian doctrine of population and the abstinence theory of interest were shown to be untenable in the forms in which the classical writers had advanced them, and less simple theories having more regard to the complexities of the subject were proposed to take their places.

Through the combined operation of all of these influ-

ences the inadequacy of the classical system was proved both inductively and deductively, and the way was prepared for the more careful and scientific, if less confident and sweeping theories of economics which are now accepted.

In turning from this brief survey of the history of the science of economics to an account of present-day principles and problems, I am filled with renewed admiration for my predecessors who have succeeded in telling so much about their subjects in the limited time allotted to them.

Although it is one of the newest of the sciences, economics has already been subdivided into many special branches, to any one of which a lecture such as this might profitably be devoted. Statistics, mathematical economics, economic theory, public finance, practical economics, economic history, and social economy are the branches at present represented through special courses or series of courses offered at this University. In each of these notable progress is being made. Not only is our mastery of the essential facts in regard to industrial conditions in this and other lands becoming every year more complete, but greater care is constantly being exercised in the formulation of the premises to be used in economic reasoning and in the application of theoretical conclusions to practical problems. Notwithstanding this progress, the present state of development of the science is still one of transition. The dogmatic orthodoxy of the past has been succeeded by an exuberant heterodoxy which gives so great prominence to the disagreements among economists that the agreements are easily overlooked. This disputatious period is gradually passing in its turn and a new body of principles is emerging which entitles economics still to be regarded as the most exact of the relatively inexact social sciences.

One of the chief difficulties with which economists have all along contended is the inexactness of their terminology.

It is a significant indication of present tendencies that at the last meeting of the American Economic Association a standing committee was appointed on "agreements in political economy." The principal task assigned to this committee is that of formulating standard definitions of the more common economic terms. It is hoped that by this means a more truly scientific terminology may gradually be developed, which will not only contribute greatly to clearness of thought, but put an end to the merely verbal controversies to which in the past far too much attention has been given.

In the limited time that remains to me it will be impossible to deal with many of the phases of contemporary economics. Great as is the temptation to enter upon a discussion of those problems that are just now most prominently before us in the United States, the currency question, the railroad question, the trust question and the tariff question, I feel that I shall give a truer impression of the relative significance of different parts of economics if I pass them by in favor of problems pertaining to labor. For, as Professor Marshall has said, it is after all the question "whether it is really impossible that all should start in the world with a fair chance of leading a cultured life, free from the pains of poverty and the stagnating influences of excessive mechanical toil * * * * * which gives to economic studies their chief and their highest interest." To explain why and in what respects the present attitude of economists toward labor problems differs from that of the classical writers, I must begin where I left off in expounding their theories,—with the problem of distribution.

The explanation of the division of the annual products of industry into the shares into which they are distributed, that is now widely, though not yet universally accepted by economists, is conveniently designated as the "productivity

theory." According to this theory as it applies, for example, to the share of the annual produce that goes to wage-earners, it is not the fund of wealth that has already been accumulated that determines wages (as held by the wages-fund theorists), but rather the flow of wealth which is being currently produced. Employers, when deciding what wages they can afford to pay, consider not the capital which they happen to have, but the probable value of what their employees will produce. Having decided what their employees are worth to them, or, what is the same thing, what the part of the product attributable to their labor is worth, they, of course, try to secure their services for less. If competition is perfectly free, however, and employees are alert to their own interest and willing to shift from one employer to another for the sake of higher wages, the competitive demand for labor among employers will force wages up until there is little margin between the wages paid and the value of what labor produces.

In the same way that it tends to assign to wage-earners the share of the product that is imputable to their labor, the free play of competitive forces tends to assign to land and the other instruments of production their respective shares of the joint product. This does not mean, of course, that the tendency of free competition is to deprive employers of their profits. The productivity theory makes full allowance for ordinary profits, or wages of management, and also for the additional profit or loss which falls to the employer because he assumes the risks of business. It asserts merely that competition tends to cause all the different shares in distribution to correspond to the parts of the product that are economically imputable to the services which the corresponding factors render in production. The explanation of the process by which this economic imputation is carried out amidst the complexities of modern business relations is one of the most difficult tasks of economic analysis. For

proof that it is carried out, I must refer you to the technical manuals, of which, as President Butler once said of small colleges, three are supplied by Columbia.

In accepting the productivity theory of competitive distribution, economists do not ignore the fact that the assumed state of perfectly free competition is very far from being realized in actual industrial society. They recognize fully that monopoly, to mention only one complicating factor, plays an equally important rôle with competition in determining actual distribution. Thus the laws of competitive distribution are merely a point of departure for studying the problems of actual distribution. To understand the latter, allowance must be made for the element of friction in economic life in somewhat the same way that such allowance is made in physics in applying the laws of motion to the actual movements of falling bodies. The chief difference is that in economics the element of friction is often of such dominating importance that the utility of the explanation of what would happen if competition were free is sometimes questionable.

Recognizing fully the limited application of the productivity theory, I nevertheless believe that acceptance of it has been an important factor in changing economics from a "dismal science" to a science full of promise for the future of industrial society. Merely to assert that wages depend fundamentally upon what the wage-earner produces is to make an appeal to the ambition and enterprise of the working masses. If wages are low, a certain way to raise them is to make labor more efficient. Thus the interest of wage-earners becomes identical with the interest of the whole community. Rising wages mean an increasing output of wealth on the part of wage-earners. They are not opposed to the interest of any other class—to that of employers, of capitalists, or of land-owners. On the contrary, the increasing wellbeing of wage-earners

means increased wellbeing for all classes. Thus all should unite in promoting plans for the better education and training of the world's workers, and the benefits which will flow from such efforts will be cumulative, because the higher earnings of the more efficient workers of one generation will almost inevitably be used in part for the benefit of the workers of the next.

The acceptance of this theory has also led to a clearer analysis of the part which capital plays in production. The classical economists when they spoke of capital habitually thought of the imaginary wages-fund. The principal function of capital to them was to feed and support the laboring masses while they were devoting themselves to the production of unfinished forms of wealth. To modern analysis the principal function of capital is to supply the tools, machines, railroads, factories, and other instruments which so enormously increase the productiveness of industry. While denying the existence of a special wages-fund, economists do not of course ignore the fact that it is a second function of capital to make possible the elaborate division of labor and the roundabout methods of production, which in their turn contribute so largely to the productiveness of industry. In order that production, distribution and consumption may go on regularly and continuously, a vast accumulation of wealth in the form of raw materials and partially finished and finished commodities is necessary. By recognizing that it is the function of capital to supply the instruments of production as well as this fund of materials, economists now define the relation between labor and capital in a way that neither humiliates the workman nor belittles the importance of the part which capital plays in production.

A third important consequence of acceptance of the theory that wages tend to equal what labor produces is that economists have come to feel that this is the lowest

standard of remuneration that is compatible with justice. The worker is entitled at least to the full equivalent of what he produces. This is the moral principle which economists now very generally apply to the labor situations on which they have to pass judgment. Very often, perhaps more often than not, the ideal standard of the productivity theory is not realized in practice. Wages fall below, sometimes far below the fair equivalent of what labor produces. This may be due to the fact that a given branch of industry is controlled by a monopoly; to an open or tacit combination among employers not to spoil the labor market by bidding up wages; to the ignorance, inertia or timidity of wage-earners themselves; or to the fact that the advantages of industrial progress redound first to the benefit of employers and that it takes time for wages to be advanced so that the workers get their share. Recognition that some or all of these influences may prevent workmen from getting the wages to which, according to the productivity theory, they are economically entitled, has made economists much more sympathetic toward labor organizations than they used to be. From condemning them as useless, if not harmful, they have changed to approving them as necessary means of putting wage-earners in a position to bargain on equal terms with their employers. When the latter are giant, semi-monopolistic corporations, as is so commonly the case today, it is clear that the workmen stand little chance of getting a fair competitive wage unless they organize to oppose combination on the side of capital with combination on the side of labor. Thus, in place of the older conception of a competitive labor market in which isolated employers competed against one another in bargaining to secure the services of isolated and competing wage-earners, the present conception of a desirable labor situation is one in which honestly and intelligently directed labor organizations enter into collective

bargains with honestly and intelligently directed employers' combinations. It is believed that such a situation will not only result in fairer rates of wages, but that it will serve as an effective restraint on the embittered conflict between capital and labor which is now such a menace to continuous prosperity.

The same considerations that have led economists to approve of labor organizations have made them advocates of legislative interference to control the conditions of the labor contract. Reasonable laws regulating the working hours of women and children and prescribing standards of sanitation and safety for the benefit of all employees are today universally approved by economists. The legal regulation of the hours of labor of adult men is less generally demanded, but the industrial development of progressive countries is so clearly away from the situation in which effective individual liberty results from a policy of non-interference on the part of the government that the argument for protective labor laws for all classes is steadily gaining adherents. The object and tendency of such laws, as economists now recognize, are not to repress individual initiative and enterprise, but rather to determine the plane on which initiative and enterprise shall act. Enterprise which spends itself in devising new methods for sweating the last ounce of productive power out of underpaid and ill-fed employees serves no useful purpose. It is much better that the same energy and ingenuity be directed toward introducing more efficient tools and machinery or a better division of labor, wage-earners meantime being protected from over-work under unwholesome conditions by definite legal prescriptions.

Economists approve of trade unions and labor laws, because they recognize that their assistance is needed to protect wage-earners from the destructive effects of an unfair, because unequal, competition. But their program

on behalf of wage-earners does not stop here. Side by side with the principle that wage-earners are entitled at least to the full equivalent of what their labor produces, most economists would now put the further principle that wage-earners should be protected from losing through accident or misfortune the capacity to maintain the standards of living to which they have become accustomed.

Among the contingencies which frequently prevent the families of independent and self-respecting wage-earners from preserving their standards of living the principal are sickness, accident, unemployment, premature death and old age. One way of providing against these evils and the way on which the classical economists relied is for every wage-earner to accumulate an independent fund of capital. Desirable as would be such a development, no one can deny that the progress which wage-earners have made in this direction is exceedingly slight. Moreover it is not the most economical and intelligent way to meet these contingencies to which all are liable, but which the great majority escape in whole or in part. A better way is through the machinery of insurance, by which a common fund is created for the benefit of those who suffer from these evils at a minimum of expense to the larger number who are exposed to them.

Insurance against accidents, premature death and old age, and even against sickness, have long been furnished by commercial insurance companies. The trouble is that those who would be most benefited by this insurance are either indifferent to it or unable to bear the expense of securing it. Under these circumstances some plan of universal insurance at the expense either of the wage-earners to be benefited, of their employers or of the state, seems alone suited to the necessities of the situation.

Time will permit only the briefest reference to the different plans of universal insurance against these evils

which are being tried. Germany, as is well known, has developed a system of universal compulsory insurance against all of them except unemployment. The United Kingdom has recently extended its system of workmen's compensation for industrial accidents until it includes not only practically all employments, but also certain diseases contracted in connection with the occupation. Denmark, New Zealand and New South Wales have established old age pensions, and it appears probable that the United Kingdom and France will also establish them so soon as the additional revenues which they necessitate can be provided. Finally, certain German and Swiss cities have experimented with systems of municipal insurance against losses due to unemployment.

The point I wish to emphasize is that these measures, which to the classical economists would have seemed opposed to all of the principles of economics and sound statesmanship, are now approved in substance by a large and growing body of the younger generation of economists. More careful analysis and completer knowledge of the facts of industrial life have discredited many of the arguments which the older economists urged against such measures, and experience of the actual results that follow from them has shown how groundless was the fear that they would prove subversive of public order and good government.

The reasons for this change in the attitude of economists may be illustrated by taking up in a more concrete way one of these contingencies which it is proposed to provide against by some plan of universal, state-controlled insurance. The change in opinion in reference, for example, to industrial accidents is instructive. The older economists thought that competition would cause wages to be sufficiently higher in dangerous trades to compensate workmen for the risks they run. Wage-statistics prove

that this is not the case. The facts overlooked by the older writers were that wage-earners are both ignorant of and indifferent to the dangers to which they are exposed. But if wages are not higher in dangerous trades, workmen and their families ought to be protected in some other way against the losses industrial accidents entail. These losses are really portions of the cost of producing goods. Consumers, therefore, for whose benefit production is carried on should be made to pay for them. But consumers cannot be reached directly. The simplest plan is to throw the cost of workmen's compensation upon employers and depend upon them to pass it on to consumers, as they do their other expenses of production, in the form of somewhat higher prices for their products. Under this plan consumers pay for what goods cost in maimed bodies and shortened lives, as well as for what they cost in wear and tear of plant and used up raw materials. No one has reason to complain of the new policy and a great social evil is remedied.

As for industrial accidents, so for the other evils that have been enumerated, economists are now convinced that no merely individualistic remedies are adequate. The individual, even the intelligent individual, is too confined in his outlook and too blinded by belief in his own immunity to take the measures for his protection which the situation calls for. Such measures to be adequate must be comprehensive. Based on full knowledge of the social consequences of the evils to be remedied, they must be adopted as parts of a constructive policy of social betterment, and compulsion must be used to bend the will of the individual to what is so clearly for the general good.

Does this change in the attitude of economists in reference to labor problems mean that they are becoming socialistic? If "socialistic" is used to designate every departure from a rigid *laissez-faire* policy, then the economists of to-

day are undoubtedly more socialistic than were the economists of thirty or even ten years ago. Most economists, however, would draw a sharp distinction between the widened field of activity on which they desire to see the state enter and socialism. To eager socialists every step in the direction of a broader social policy appears to be a step toward their cherished goal. But it is a long road that has no turning. The road which progressive countries are now traversing is undoubtedly away from the narrow individualism of the past; but the novel social policies which are being tried in this country and in that may prove not advances toward socialism, but rather bulwarks against the revolutionary changes in our fundamental institutions of private property and freedom of contract which socialists advocate. It was with this deliberate purpose in view that Germany took the lead in this field of social legislation in the early eighties. And it is with this expectation that most economists have lined themselves on the side of such legislation. But it is a rash prophet who would attempt to say just how far the extension of governmental functions may go without narrowing, instead of widening, the field of effective individual liberty. One great change that has certainly occurred is that the cry of socialism has ceased to weigh with intelligent people as an argument against any proposed policy. The question which interests present-day economists is not whether a given measure is socialistic or individualistic, but rather whether, considering all its effects direct and indirect, it is socially expedient. In this spirit they welcome experiments along socialistic lines; but with a caution born of knowledge of past failures they prefer that the more radical of these experiments be tried by other countries first. This change is only part of the larger change that has occurred in all fields of thought. In desiring to see the contentions of socialists submitted to experimental proof, rather than

silenced by *à priori* objections, economists merely exhibit their kinship with scientists in other fields. They also distrust the absolutist temper and prefer the open mind.

In these lectures it has become the custom to say something about the motives which dominate specialists in the different fields of knowledge that are passed in review. As regards economics, the principal incentive of those who have most distinguished themselves in the science has certainly not been mere love of truth. Economists love truth, I hope, as ardently as the natural scientists. They also find outlet for their play instinct in the intellectual exercises afforded by the problems which they are endeavoring to solve. Were it not, however, that they hoped to contribute ever so little to the progress of industrial society toward a more satisfactory adjustment of its burdens and rewards, few would continue to devote themselves to a specialty which presents so many baffling and discouraging features. While not insensible to the ideals of scientific accuracy and fidelity to truth which inspire all honest scholarship, economists are, therefore, frankly utilitarian in their motives and aims.

Looking back over the development of their science during the last one hundred years, economists have many reasons for satisfaction. That the science itself should have made progress is a matter of course. What was not so inevitable is its increasing influence on other fields of thought and on practical policies. Historians, who, used to stigmatize insistence on the importance of industrial history as narrow and doctrinaire, are now willing to concede everything that reasonable economists would claim for this special branch of investigation. As economists have grown more modest and more truly scientific, practical business men have become less prone to brush aside their arguments as "mere theory" and more ready to recognize that the social aspects of business also merit considera-

tion. Even more gratifying is the increasing part which economists are being allowed to play in the drafting of legislation and in the administration of laws whose enactment they have helped to secure. The appointment of economists on tax commissions, industrial commissions, trust commissions and labor commissions has become so common as now to be taken for granted even in the United States, where it is a very recent development. In fact, the appreciation in which economic studies are held is growing so general that there seems just now danger that too much, rather than too little, importance may be attached to the views of academic economists. When, as recently in a neighboring state, a judge of one of our highest courts solemnly declares that the time is at hand when the courts of last appeal will cite the writings of economists rather than legal precedents in justification of their decisions, the sense of elation that economists cannot but feel is tempered by misgivings as to their preparedness for this serious responsibility. The one reassuring thought which encourages them when they contemplate the extent of their ignorance is that which Professor Robinson threw out as a life preserver to support his historical colleagues through the flood of his destructive criticism. Little as economists know about economics, they at least do not know less than anybody else.

But the chief reason for the economist's satisfaction is, after all, the change in his own attitude in reference to social progress. The wages-fund theory and the Malthusian doctrine of population made economics seem a dismal science to the idealists of the first half of the nineteenth century. The theory of distribution that is now accepted and the practical measures which follow from it have changed economics into a science full of hopefulness for the future. Disagreeing still on some fundamental problems and on many of the practical applications of eco-

nomics, the economists of today are nevertheless gradually coming to agreement. Moreover, out of the clash of their conflicting opinions a definite program of economic reform is emerging, which promises to make them as effective in promoting a broad and liberal policy of social betterment in the future as they have been in some periods of the past in sincerely, but mistakenly, opposing every departure from a strict *laissez-faire* policy. Economics still lacks the charm for the scientific mind that comes from precision of statement and exactness of reasoning from premises to conclusion, but no one need now be deterred from studying it from the fear that it deals with colorless abstractions or leads to a jaundiced view of life. It is intensely human in its interest, and the goal of progress toward which it points is as full of promise of wellbeing for mankind upon this earth as have been the dreams of poets or the aspirations of philosophers in any by-gone age.

POLITICS

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
FEBRUARY 12, 1908**



POLITICS

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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published June, 1908.

POLITICS

EVERY science begins by laying hold of some definite and tangible facts, and advances by tracing their myriad relations until they are lost in the great complex of things. So politics starts with the government which, in final analysis, is a determinate number of persons in a political community charged with certain public duties, and it advances to a consideration of the phenomena which condition the organization and operations of the government.

It is evident at a casual glance that official performances are not really separable from other actions of the governmental agents themselves or from many of the actions of citizens at large. For instance, the declaration of war against Spain was a political act, but clearly it was only an incident in the sum total of events which led up to the armed conflict. For months before the official proceeding, social forces had been gathering strength, and impinging on the minds of persons charged with transmuting the feeling and will of the nation into the legal state of war. It was by a mere formal process that social realities passed over into political facts. To cite another example, an alderman voting in a regularly constituted assembly in favor of purchasing a plot of land for a park performs a political act in the strict sense of the word; if he gives a friend a quiet suggestion to engage in real estate trans-

actions near the proposed park, his procedure is none the less political though it is not clothed with official sanction.

It is apparent that the jural test of what constitutes a political action draws a dividing line where none exists in fact, and consequently any study of government that neglects the disciplines of history, economics, and sociology will lack in reality what it gains in precision. Man as a political animal acting upon political, as distinguished from more vital and powerful motives, is the most unsubstantial of all abstractions. The recognition of this truth has induced students of politics to search in many fields for a surer foothold than law alone can afford. This inquiry has led in such varied directions as to cause a recent German writer on political science, Professor Jellinek, to declare that the fundamental problems of state are neglected in favor of social questions, while microscopic methods of research into minute matters have destroyed the earlier rock-founded dogmas and left nothing behind but disconcerting doubts.

It is, however, to my way of thinking a false notion that the ancient and honorable discipline of politics has been overthrown or absorbed by the dissolution of the subject into history, economics, and sociology. Rather does it seem that solid foundations are being laid in reality in place of in the shifting sands of speculation. We are coming to realize that a science dealing with man has no special field of data all to itself, but is rather merely a way of looking at the same thing—a view of a certain aspect of human action. The human being is not essentially different when he is depositing his ballot from what he is in the counting house or at the work bench. In place of a “natural” man, an “economic” man, a “religious” man, or a “political” man, we now observe the whole man participating in the work of government. Politics starts with the observation of such of his acts as may be juristically tested, passes to

the acts most nearly related, and then works out into the general field of human conduct. In describing the forms of government, in seeking the historical and social reasons why government in Germany differs from that in France; in explaining the elaborate details of administration; in endeavoring to penetrate the sources of party organization and operation; in comparing the political experiences of different nations, politics has a definite field of its own, even if it does not meet the approval of the high priests of the mathematical and the exact.

It may be conceded at the outset that politics does not possess a single piece of literature as substantial as a table of logarithms or an engineer's handbook, nor a body of doctrine to be applied with celerity as a form of first aid to the injured. And after all, the men of pure science must admit that politicians are scarcely more disputatious over the best form of a primary law than are consulting engineers over the problem of ventilating the subway. In fact all knowledge, when applied to specific problems, even in many branches of natural science, is often at best a dim light, and political knowledge suffers from this general limitation on the human intellect. In spite of the many troubles that beset him, however, the student of politics may rejoice in an ever growing body of sound material, historical on one side, descriptive and statistical on the other.

Archaeologists and anthropologists are disclosing to us primitive types of society which were as unknown to Aristotle, Hobbes, and Locke, as the flora of the tropics were to the mediaeval botanist. Vast collections of laws, documents, chronicles, and miscellaneous papers, revealing step by step the processes in the origin and development of the state, have been edited with scientific care by historical investigators. Great treatises like those of Stubbs, Maitland, Gierke, Brunner, Coulanges and Spencer have put

the student of politics further in advance of Montesquieu than he was ahead of Marsilius of Padua of the fourteenth century. Governments are now taking censuses on an ever larger scale and on more scientific principles; bureaus are obtaining and arranging data on political experiments of every sort, from the working of old age insurance in Germany to land taxation in New Zealand. Private persons, like Charles Booth in his survey of London, are laying bare realities once the subject of futile speculation and thus outside the range of effective political action. From this vast heterogeneous mass of materials are coming an ever sounder notion of the origin, functions, and tendencies of the state, a higher view of its possibilities as the experiments of each nation are placed at the disposal of all, and finally a more scientific theory of causation in politics.

One of the most salutary results of this vast accumulation of data on politics has been to discredit the older speculative theorists and the utopia makers. Even their very interests and presuppositions are being rudely brushed aside. For example, Locke devoted about one half of his famous "Treatises on Government" to showing (1) that Adam had not by natural right of fatherhood or by positive donation from God any such authority over his children or dominion over the world as Filmer had pretended; (2) that if he had, his heirs had no such right; (3) that if they had, there was no sure way through the law of nature or the positive law of God of knowing who was the right heir; (4) and even if this could be determined, the knowledge of which was the eldest line of Adam was so utterly lost that it was impossible to discover the eldest house. After having rejected the Adamite source of political authority, Locke proceeded to base his reasoning on an equally unhistorical proposition that "To understand political power aright and derive it from its original we must consider what estate all men are naturally in and that

is a state of perfect freedom to order their actions and dispose of their possessions and persons as they think fit within the bounds of the law of nature without asking leave or depending upon the will of any other man."

Quite different from this is the procedure of the student to-day. If he wants to discover how government originated, how its forms have changed, the tendencies of its evolution, and the forces modifying its structure and functions, he knows that there is no hope for real knowledge except in the painstaking examination of the materials that are left to us—records of past politics, statistical materials on races, groups and classes, and descriptions of the bewildering types of society gathered from the past and from the four corners of the earth.

The influence of the historical school on correct thinking in politics has been splendidly supplemented by that of the Darwinians. They have given us as the political unit not a typical man with typical faculties, but a man infinite in variety and capacity, ranging from the dog-faced cannibals of the Andaman islands to the highest type of modern citizen who surrenders the hope of private gain that he may serve the state. Our primeval citizen, as Mr. Edward Jenks points out, is not "the noble savage passing his days in a sort of perpetual picnic surrounded by his family who sported in flowery meads while he discoursed sweet music," but rather in general a miserable, underfed and undersized creature, naked and shivering, houseless, in constant terror of dangers seen and unseen, with no family ties as we understand them, with no certain food supply, and no settled abode. The eighteenth century philosophers were wrong. We have not been driven from a political paradise; we have not fallen from a high estate, nor is there any final mold into which society is to be cast. On the contrary, society has come from crude and formless associations beginning in a dim and dateless past and moves outward into an

illimitable future, which many of us believe will not be hideous and mean, but beautiful and magnificent. In this dynamic society, the citizen becomes the co-worker in that great and indivisible natural process which draws down granite hills and upbuilds great nations.

Some very profound scholars, among them Sir Henry Sumner Maine, have thought that, in spite of this persistency of change, society has arrived at two fundamental notions of permanent validity, namely, freedom of contract and private property. Nevertheless, beyond agreeing that a certain freedom of contract is indispensable to the working of natural selection and that pure communism is a device for angels and not for men, recent writers seem unable to find an abiding place for contract or property. Under feudalism, as we know, some of the most elemental matters of a political nature now fixed in public law were the subjects of free arrangement between sovereign and vassal, while many other matters then determined by status are now left to private agreement. Such at least was the view of those profound students of law, Pollock and Maitland, who closed their chapter on contract with the sound conclusion: "The master who taught us that the 'movement of progressive societies has hitherto been a movement from status to contract' was quick to add that feudal society was governed by the law of contract. There is no paradox here. In the really feudal centuries . . . men could contract to stand by each other in warfare 'against all men who live and die'; they could (as Doomesday Book says) 'go with their land' to any lord whom they pleased; they could make the relation between king and subject look like the outcome of agreement; the law of contract threatened to swallow up all public law. Those were the golden days of 'free' if 'formal' contract. The idea that men can fix their rights and duties by agreement is in its early days an unruly anarchical idea. If there is to

be any law at all contract must be taught to know its place." Thus contract like other institutions falls into the flow of things; we are never compelled to choose between status or contract; but we shall have perennial questions as to the positive limits on the kinds of things which men may agree to do.

It is the same with private property. If we trace its evolution from the quasi-communism of primitive times to the age of intangible securities, we find that men's ideas have differed fundamentally as to what particular things should constitute private property. For example, man himself was once regarded as the proper subject of ownership; the feudal privileges and the tithes swept away by the French Revolution were forms of property no less real than industrial stocks; the rotten boroughs abolished by the Reform Bill of 1832 were marketable holdings; vast areas of the open seas were once claimed by Spain; and high roads were formerly private possessions. Thus some forms of property have disappeared altogether; the public has laid hold of domains once reserved to the individual; and private rights are becoming more and more penetrated with notions of public welfare. The great question of any age, therefore, is not shall private property as such be abolished, for the nature of man demonstrates that it cannot be, but what forms of property shall be permitted, and to what public uses shall they be subjected. Here politics confronts not axioms of law or polity set like the hills, but complicated social questions to be settled, not in the closet with the philosophers, but amid the multitudinous experiences of the market place where society daily meets the pressing needs of life.

It is not only in possessing sound historical and evolutionary notions that the student of politics lays claim to being more scientific than his predecessors in the eighteenth

century. He endeavors more and more to subject his own thinking to the very disciplines of history and evolution. He is convinced of what Professor Dunning has so amply and admirably demonstrated, that political philosophy is the product of the surrounding political system rather than of pure reason. The older philosophers naïvely gave expression to the opinions which logically fitted their respective environments and then apparently unconsciously assigned universal validity to their cogitations. The modern scholar solemnly warned by the fate of the older doctrinaires is on his guard against formulating into a transcendental philosophy either the emotions connected with the status quo, or the ecstatic delight derived from contemplating a perfected humanity. He has a strong suspicion that when his attention is sustained to the highest point and his so-called reasoning faculties are hardest at work, there are welling up within him and finding articulation, forces connected with his own life history and of the race and nation from which he sprang. He knows that it is an almost superhuman doctor who can set the norm for a sound mental eye.

These personal or subjective forces which distort the vision even when we would see straight are both gross and subtle, and they may be divided roughly for practical purposes into three groups—religious, class, and patriotic biases. A gross form of the religious bias is revealed in an account of a Mohammedan preacher:

“When Abd-el-Lateef, a Wahhabee, was preaching one day to the people of Riad, he recounted the tradition according to which Mohammed declared that his followers should divide into seventy-three sects, and that seventy-two were destined to hell-fire and only one to Paradise. ‘And that,’ added Abd-el-Lateef, lowering his voice to a deep tone of conviction, ‘by the mercy of God, are we, the people of Riad.’”

Examples of this mode of thought (in other places and times) will be easily recalled, and its effect on objective reasoning readily imagined.

The class bias takes its most obvious form in those countries where class divisions are frankly recognized by law. A familiar manifestation of it appeared in the British parliament in 1807, when Samuel Whitbread's scheme for popular education was met by the objection that giving instruction to the working-classes would be found prejudicial to their morals and happiness, and instead of making them content with the laborious employments to which their rank had destined them would render them insolent to their superiors. Group philosophy is not unknown in the United States. A practical politician who has occasion to make campaign speeches before various clubs and assemblages told me that it was his custom when addressing lawyers to dwell upon the beauties of the Constitution and laud the federal Supreme Court as the very best instrument for ascertaining the deliberate judgment of the American people; when speaking to manufacturers, to lay stress on the moral principles underlying a protective tariff; and when appealing to workingmen, to urge the desirability of more labor legislation. It is not only the politician who is affected by this subtle bias; it is universal in its operations; it penetrates even the closet of the philosopher who, like other men, does not begin serious deliberation until his formative years have been passed within some social category. Herbert Spencer, for example, was so steeped in Manchester economics—the general political philosophy of the class from which he sprang—that in his "Study of Sociology," which is primarily a warning against subjective prejudices, he goes into a fine rage whenever state interference has to be mentioned.

The patriotic bias has so many daily and obvious manifestations that its workings need not be considered at any

length. The author of one of the most scholarly treatises on politics within recent years concludes after painstaking inductive study that the constitutional monarchy is the highest form of government which has yet been evolved. The home of this scholar is Germany. For Burke the British constitution was an organism to be understood according to one's measure and venerated where not understood, on the general principles that there could be nothing wrong with it. Without referring to specific instances of the patriotic bias in the United States, we may say that it is a settled axiom in many quarters that our institutions are not only the highest types of political devices imaginable, but are also the expression of the genius of a superior and peculiar people.

Now all of these biases, and many more, are dangerous foes to the ascertainment of truth concerning any set of political facts—which is the real aim of scientific politics and which we have learned from the natural sciences is the best way in the long run to acquire that wisdom which exalts a nation. I wholly agree with my former teacher and friend, the late Professor Frederick York Powell, “that it is not the historian's duty to try to estimate the exact degree of damnation that should be meted out to that dauntless captain and bold statesman, Cesare Borgia, or even to his capable but unpriestly father; or to play the moral judge to such men as Thomas and Oliver Cromwell, or ‘that great king Harry VIII,’ or Napoleon.” Likewise I hold that it is not the function of the student of politics to praise or condemn institutions or theories, but to understand and expound them; and thus for scientific purposes it is separated from theology, ethics, and patriotism. I know there is high contempt on the part of many persons for the pursuit of learning that does not end in the vindication of their preconceptions, just as, until quite recently, no American history was acceptable in the North that did

not charge the South with moral depravity in addition to treason. I believe that on mature deliberation, thoughtful persons, contemplating the ruins which indiscriminate hate and fierce dogmatism have helped to make, will agree that the introduction of a little philosophic calm will not work corruption in the minds of men or undermine the foundations of society. The data secured by scientific investigation may be used by the theologian, the teacher of ethics, and the patriot for their several devices, and the student of politics will rejoice if they will use real facts in the place of pseudo-facts which are too often found in the armory of their arguments.

It is accordingly in the spirit of modern science that the student of politics turns to the great divisions of his subject, namely, the state, government, the limits of government action, political parties, and international relations. No apology need be made for placing the state first, for it is the unit in world politics; it is the highest form of human association yet devised; and with fundamental notions concerning it are connected both ideal impulses and practical policies. In common usage the word *State* is indiscriminately confused with the term nation or political community, but, as Professor Burgess has so clearly and definitively demonstrated, there can be no approach to a science of politics unless we have at the outset a somewhat precise concept of what is meant by the state.

The surface of the earth, at least of the civilized world, is now sharply divided into geographical areas inhabited by distinct political communities produced by ethnological, economic, and other factors. It is apparent to the most casual observer that not all the persons within any particular group—men, women, and children,—share in the making of laws or the conduct of government. Moreover, as Sir William Markby urges, the lawyer in dealing with

legal questions must always be prepared to prove, if it is denied, that there is a determinate and supreme sovereign or sovereign body whose intentions as regards the matter under consideration are capable of being ascertained and that the commands of this person or body will be obeyed. It is undoubtedly difficult, and sometimes almost impossible, to determine precisely the person or body within a nation which possesses unlimited underived authority over all the others and is capable, under ordinary circumstances and in last resort, of enforcing its authority. Nevertheless for juristic and political purposes such a body must exist, and in many instances it is possible rather sharply to distinguish the state from the nation, especially where there is a recognized ruling class or absolute monarch. For example, in England shortly after the Norman Conquest, the state was undoubtedly the king, from whom every inch of land was held on conditional tenure, to whom every subject owed allegiance, and whose will expressed in decrees and ordinances was undoubted law enforced by the courts and administrative officers. In time this power passed from the hands of the king to the barons, lay and ecclesiastical; later it was extended to a great portion of the adult males; and the late Sir Henry Campbell-Bannerman, as prime minister, expressed himself in favor of admitting to the charmed circle of the state at least a few of the women, now too often consigned to unhonored drudgery, the vanities, or the punctilious performance of the unimportant.

The origin of this sovereign power in the political society is an ancient question and four answers have been made to it. The theologians, in times past, have attributed to the state a divine origin: "The powers that be are ordained of God. Whosoever resisteth the power, resisteth the ordinance of God." This theory is now rejected for the same reason that the Miltonic account of creation is rejected by

students of natural science,—that is, because it does not explain the exact process by which the state came into existence, and if literally accepted would close the doors to research and understanding.

The second theory, which is generally connected with the name of Rousseau, not because he originated it but because it became such a powerful instrument of agitation in his hands, is that the state originated in a compact made in prehistoric times by free individuals. Even Rousseau did not believe the original compact to have been an actual historic fact, but it afforded him the semblance of a natural philosophy as the basis of an attack on the theologians who had a monopoly of the divine right doctrine. The third explanation of the origin of the state, associated with the name of Sir Henry Sumner Maine, views the state as the product of gradual evolution out of patriarchal authority—the original form of domination among human beings. The state is only the enlarged family. This is now rejected on the simple ground that not a single one of the states of Western Europe of whose origin we have tolerable records can be traced genetically to the extension of patriarchal authority.

The real origin of the state, in Western Europe at least, is to be found in conquest, although it must be admitted that power-bearing individuals were previously rising within the older patriarchal groups as a result of the economic discipline they were able to impose on their slaves and semi-free kinsmen. A military leader and his war band, in search of plunder and sources of steady income, conquer and fuse settled communities loosely united by kinship, and settle down upon the subject population as the ruling authority, absorbing surrounding areas by divers processes. General Blücher echoed the spirit of the ancient founder of the state when, on viewing London from the dome of St. Paul's, he exclaimed, "Was für

Plunder!" In the beginning, the power of the leader is checked by his war band, but the threads of dominion are slowly gathered into his hands, especially after he becomes king and receives religious sanction, though in the exercise of his battle-born authority he may be always thwarted or swayed on many policies by his warrior aristocracy and the Church Militant.

War thus begets the king¹; in time the king becomes the prime source of political authority and the fountain of all justice; law is enforced, decrees are issued, money is coined, and prosecutions are carried on in his name; the army is the royal army, the navy is the royal navy, the high roads are the king's; all peace is swallowed up by the king's peace. At length the war leader and anointed of the Lord stands forth in the plenitude of power, the visible and outward sign of political authority and, in spite of all limitations, the real and veritable centre of the state.

The strong king proves acceptable in spite of his sometimes cruel despotism and irresponsible actions. His peace protects merchants and cities against robber barons; his courts afford justice—rude and curious—but more certain in principle and more effective in action than the justice of the feudal castle. At his palace learning is cherished; arts and commerce flourish; a middle class of smaller landed proprietors and men of trade is created; it seeks to standardize the king by the strict rules of business. Its members ask the king not to tax them without their consent, not to seize their person or property without observing some regular public forms, not to make laws without asking their opinions. Thus constitutional government is born and thus political authority passes from the king to a portion of his nation. It is sometimes a painful process

¹ The term king is of course used in a general sense covering the whole range of sovereign titles.

for the sovereign. If he resists encroachments on his consecrated rights, refuses to conciliate, mistakes the inevitable process for temporary insubordination, then there is a cataclysm and the new form of state is created in the throes of revolution. If the king is wise he contents himself with the insignia of office and continues to symbolize the nation's unity and power. Such in brief is the story of the rise and diffusion of political authority—*i.e.*, sovereignty. It rests not on vacuous speculation, but upon the results of laborious research and patient winnowing on the part of innumerable historical scholars.

It is evident that in this diffusion of political power among the masses the state has lost its ancient definiteness of form, for it is difficult to discover not only who compose the state from the standpoint of law, but also where among those enjoying nominal sovereignty is the real power. As we pass from the relatively simple state such as we find in England shortly after the Norman Conquest, when the king was the virtual sovereign, to the state as we find it to-day, it becomes increasingly difficult to determine precisely the seat of real authority. True, it is relatively easy to ascertain the precise number of British who are by law entitled to vote for members of Parliament, and one might say that this is the legal sovereign in Great Britain. But if we press the analysis further, we must go behind the ballot box to the psychological forces controlling the action of the individuals composing the state, and when we try to get hold of power in a political sense we find it exceedingly elusive. It is clear that these thousands of units making up the state are not all equal in intelligence or influence. It is also evident that a great portion of them do not exercise the power which they lawfully have, that another portion has no very lively consciousness of the motives on which it acts, and that the actual will of the state in any one instance is merely that of a majority at best. This problem

has received very little attention from students of politics, but it would seem that the real state is not the juristic state, but is that group of persons able to work together effectively for the accomplishment of their joint aims, and overcome all opposition on the particular point at issue at a particular period of time.

Since the essence of the state is the exercise of sovereign authority by some person or group of persons, it is evident that from the standpoint of jurisprudence there can be only three forms of state—monarchical, aristocratic, and democratic—the rule of the one, the few, or the many. Changes in the form of the state have been caused primarily by the demand of groups for power, and in general these groups have coincided with economic classes which have arisen within the political society.

Corresponding with these three principal stages in the evolution of the forms of state, there have been three general types of government, considered in their fundamental nature rather than their accidental structural aspects. In the absolute monarchy we find the unlimited rule of the sovereign who, in the language of Bossuet, “needs render account of his acts to no one.” In the use of the instruments of government, even where they are taken from primitive popular institutions, the absolute monarch is, in law and fact, irresponsible and unrestricted, save by the limitations of nature and the possibilities of revolt on the part of his subjects. In the aristocratic state, where the prerogatives of the sovereign are in reality shared by a portion of his subjects, the agents of government are positively limited by the effective will of the minority thus admitted to power. The result is a balancing of the titular sovereign against the interests of those who divide dominion with him, and the establishment of a disjointed government, inefficient for positive action on a large scale

and characterized by that irresponsibility which division of power inevitably engenders. In the democratic state, where the rule of the majority is frankly recognized (a condition of affairs gravely feared by the framers of our Constitution), government tends toward a type, unified in internal structure, emancipated from formal limitations, and charged with direct responsibility to the source of power.

This tendency in the evolution of state and government has been fully grasped by many students in the United States who have broken away from the familiar notion that we are living under a peculiar dispensation in the matter of political institutions. President Woodrow Wilson opened the way a few years ago by his splendid study of Congressional Government, in which he protested against further belief in "political witchcraft," urged a frank consideration of the defects of the Constitution, and concluded with the trenchant words: "The prompter we grow in applying with the unhesitating courage of conviction all thoroughly tested or well-considered expedients necessary to make self-government among us a straightforward thing of simple method, single, unstinted power and clear responsibility, the nearer we approach to the sound sense and practical genius of the great and honorable statesmen of 1787." Two other American scholars, Mr. Henry Jones Ford and Professor Goodnow, have further advanced clear thinking on American politics by revealing the intimate character of the relation between our democratic society and the framework of government built upon eighteenth century ideas, which were misunderstood by their formulators and have been abandoned by the nation from which they were originally drawn. These scholars have conclusively shown the unreality of the doctrine of divided powers, and the positive fashion in which our democratic political society seeks through extra-legal party organiza-

tion to overcome the friction of a disjointed machine. They urge that a separation of powers is in practice impossible, claiming that the function of government is two-fold—the expression and execution of popular will—and that the body that wills must, in the nature of things, control the body that executes, if government is to be efficient. Following out this contention, these writers maintain that our strong party machinery is the extra-legal instrument with which democracy strives to obtain that co-ordination of legislative and executive functions, which is indispensable to orderly and effective government, and which is secured in England by positive parliamentary custom. They admit, however, that this attempt to control through powerful party engines is fraught with serious evils, that the confusion and division of authority among the organs of government render direct and transparent responsibility impossible, and that an element of uncertainty and distraction is added by our practice of submitting complex social and economic questions to the juristic tests of the Courts, which in the case of the federal government are practically uncontrollable (save by what are generally regarded as highly undesirable methods) owing to the difficulties imposed by the amending system.

Since radical changes in the framework of government are outside the field of practical politics at present, there has been a decided tendency recently to attempt the establishment of responsible government by securing, through primary legislation, the responsibility of the party organization which operates the government. Provision for popular control of party has gone so far in Wisconsin as to require the nomination of practically all candidates by direct vote. Other states have gone farther and sought more effective supervision in the form of direct legislation, placing the popular will above all governmental instruments. To some this seems to be adding only cumbersome com-

plications to our politics, but to others it appears to be only our circuitous way of achieving legislative responsibility.

In thus coming to recognize in clear and direct responsibility the essence of democratic government, American students are changing many of their earlier notions about the details of administrative organization. They no longer believe that democracy requires the election of every officer from the street sweeper to the state health commissioner, and they are now advocating centralization of administration (once regarded as a species of original sin) and secure tenure for technical officials as the primary necessities of efficient government. Where responsibility can be firmly and unequivocally secured, power may be safely entrusted to the agents of government, and to meet the great centralizing tendency in our economic institutions (the basis of all political institutions) power must be so entrusted, in order to administer effectively the very laws upon which the permanence of popular government depends. ✓

The enormous burden which maintenance of this extra-legal responsibility has thrown upon the political party in the United States has given it a peculiar position in our political system, though its operations were almost neglected by our students until Mr. Bryce called attention to them. Now we are becoming alive to the fact that juristic descriptions of the forms of government incur the danger of being mere abstractions when party customs are left out of account. For example, the jurist in describing the Federal government will say that the House of Representatives elects the speaker, but as a matter of plain fact the speaker is really selected by a caucus of the majority party held after many dinners and political tempests; and moreover he is really a party leader controlling with the help of the rules committee the business of law making. Constitutional law has nothing to say about committees, but everybody knows that our laws are made by the

speaker, committees, and log-rolling rather than by that body of wise men known to the Constitution. Examples might be multiplied indefinitely and the story pushed so far that a practical treatise on government would give party organization and methods the text, and reduce the formal law to the foot-notes.

Patent and important as this fact is, the student of politics is compelled to admit that we have no scientific descriptive works on the formal organization of parties or their real practices. We have, it is true, many works purporting to relate the history of parties, a few excellent studies such as the beginnings made by Ostrogorski and Bryce, and no little theorizing on the functions of parties, but we have no account of the actual historical processes by which the party has arisen and, as an extra-legal institution, controls the legal forms of government. Rich as are our political and social statistics, we have made no considerable attempts to discover inductively the precise composition of parties or their relation to surrounding social and economic phenomena. We have no philosophical treatise on the process by which the party becomes an institution commanding allegiance and punishing for treason. Under these circumstances it seems to me that the party in general and particular, as a centre of power and a working institution, offers the richest field of investigation now open to the student of politics, and the results of really scientific investigation would have the highest theoretical and practical value.

The work of the student of politics is by no means complete when he has described the forms of state and government and the operations of the latter through party control, for underlying all problems of politics is the fundamental question of the limits on government interference with individual activity. During the early part of the nineteenth

century it was thought in certain quarters that this problem was settled for all time by the solution advanced by the *laissez faire* school who proposed to limit the functions of government to the maintenance of peace, the protection of property, and the enforcement of contracts—"anarchy plus the police constable." This philosophy exactly met the needs of small manufacturers and traders seeking to free themselves from the entanglements of guilds, and regulations which had originated in the middle ages, and it had a simplicity and precision that made it appear axiomatic to those to whose interests it corresponded.

Nevertheless, like all other political philosophies, the doctrine of *laissez faire* has been compelled to submit to the limitations imposed by theoretic criticism and the march of events. On one hand, it was pushed to extremes by that type of anarchist, conscious or unconscious of the nature of his philosophy, who agreed with the *laissez faire* school that the government was a necessary evil and the "tooth and claw struggle" was decreed for all time from the foundation of the world. This rebel against the institution of government went to the logical extremity of declaring that governmental intervention to protect private property, especially in the form of inheritance, was a violation of the first principles of competition—the struggle of all against each and each against all, resulting in the survival of the fittest.

On the other hand, the beneficent results of buying in the cheapest market and selling in the dearest, regardless of all human considerations and the waste it entailed, were not realized in the social life of England during the period in which the doctrines of *laissez faire* were at their height. Indisputable evidence of the distressing state of affairs is to be found in the bulky volumes of the parliamentary reports, in the memoirs of the enlightened men who investigated the conditions in the factory centres, and in the dry

pages of the statutes revealing the wrongs which parliament sought to remedy. The humanitarians, Carlyle, Kingsley, and Ruskin, protested against "the dismal science of the millowners" and the ghastly consequences of its acceptance, and after considerable time had elapsed the scholars came to see the palpable untruth in the statement that the government has no concern in economic matters. The government defines what shall be the subjects of private property, provides the laws of inheritance, places burdens in the form of taxation, prescribes the terms on which corporations are formed, in short fixes the entire juridical framework in which economic laws operate—a fact too often neglected by political economists. In time men came to learn that society is no more a fortuitous collection of warring individuals than one of Beethoven's symphonies is a mere chance assemblage of individual notes. Evolution in the business world also rendered obsolete the abstract propositions of *laissez faire* which were tenable enough before the universal extension of the factory process and the organization of business in national and international forms. As a result of philosophic considerations and the pressure of fact no student of politics to-day will attempt to lay down dogmatically what government in all times and places should undertake to do, for he realizes that what the government does in practice depends not upon any theory about its proper functions, but upon the will of the group of persons actually in control at any one time or upon the equilibrium that is established through conflicts among groups seeking to control the government.

Turning from the field of theory to practice, we find that three powerful forces are now at work pressing for an increase in the functions of government. First in order of historical importance is paternalism or the effort of the upper classes (through sympathy or fear) to advance the

interests and security of the working-class. Its philosophy was revealed by Bismarck in a speech on labor legislation in Germany: "Give the workingman the right to work as long as he is healthy, assure him care when he is sick, and maintenance when he is old. . . . If the state will show a little more Christian solicitude for the workingmen then the socialists will sing their siren song in vain." This form of state interference, which originated in the quasi-paternal relationship of feudal lord and dependents, and in the desire of benevolent despots like Frederick the Great to increase the arms-bearing and tax-paying population, is less popular among the more purely individualistic industrial nations where the cash nexus has more fully supplanted the personal relation.

A second group of advocates of increased government activity is fundamentally individualistic in the old sense of the word, inasmuch as its members seek to use the arm of the law to destroy, or closely restrict, large corporations in order to encourage the diffusion of real property and the intensification of competition. Thus we have the paradox of extreme individualists calling on the government to interfere in economic matters to a certain degree for the purpose of forestalling the possibility of a future intervention on a larger scale. It may be urged that these advocates are immeshed in the obsolete notions about a "natural" or static state, but so long as there remains a large number of persons possessing small portions of real property, this view of the government will persist. As the possession of the visible or tangible property diminishes either through the elimination of the small property class or its passage over into the stock-holding groups, the advocacy of this type of government intervention tends to disappear and in its place comes the demand for that form of interference designed to fortify securities by the maintenance of some realities in them.

A third force working for state interference is the constant increase in the huge industrial army that inevitably accompanies the advance of mechanical revolution in production and distribution. The mediaeval system in which each worker owned and controlled his simple implements and conducted his business in his own fashion has disappeared forever and in place of it has come a divorce of the laborer from his tools—the ownership and management of which have passed largely into the hands of a relatively small proportion of the population. It is demonstrable, of course, that there are gradations of fortune in modern industrial communities and that persons are constantly passing from the working-class into other ranks, but this should not be permitted to obscure the permanence of that class itself as an inevitable concomitant of the industrial revolution. There is therefore in every western nation a vast class of persons without land, tools, or homes, dependent for a livelihood upon the sale of their labor power, and subject to the fluctuations of modern business.

As the doctrines of divine right formerly had no permanent validity for the rising middle class, so the doctrines of individual liberty—trial and indictment by jury and due process of law—do not have the same reality to the workingman that they have to members of the possessing group. Freedom of contract between an employer and an employe with a few days' supplies behind him obviously cannot have the same meaning that it has between persons similarly situated as far as economic goods are concerned. To discourse on the liberty afforded by jury trial to a man who has never appeared in a court but often suffers from considerable periods of unemployment is to overlook the patent fact that liberty has economic as well as legal elements.

Quite naturally this new industrial democracy is evol-

ing a political philosophy of its own, confused and inarticulate in divers ways, but containing many positive elements ranging from minor modifications of the labor contract to the socialist doctrine that the passive ownership of property is merely a special privilege to be eliminated by the use of the government as the collective instrument for the administration of all important forms of concrete capital. With the large implications of this new philosophy, the student of politics need not tarry unless he is of a speculative turn of mind, but its concrete manifestations in the form of labor parties, and the precise nature and points of their pressure on existing governmental functions constitute a new and important branch of research and exposition.

As a result of all these forces and the growing complexity of our civilization, along with the increasing possibilities of effective collective action, the burdens of our governments tend to multiply, and the stress once laid on individual liberty in the juristic sense is being diminished. For example, all the numerous constitutions of France from 1791 to 1875 laid great emphasis on the rights of man, but the last and most enduring omits practically all references to the primordial principles. The imperial constitution of Germany has no section on private rights; the new constitution of the Australian commonwealth leaves individual liberty without a clause while empowering the government to establish old age and invalid pensions, provide for industrial conciliation, and acquire railways and other forms of property. Moreover, our own Congress, in obedience to these new economic forces, seems willing to stretch to its utmost its powers of regulating industrial operations and protecting the working-class; and in its extension of the notions of the police power, the Supreme Court reveals the existence of this new pressure in our political jurisprudence.

A fifth and, in certain aspects, almost new division of political research may be denominated world politics. Of course we have long had treatises on the history and forms of diplomacy and also upon international law as a system of rules recognized and enforced by the tribunals of enlightened nations. But the marvelous expansion of trade and commerce which have refashioned the map of Africa in our own day, awakened the slumbering nations of the East and the islands of the seas, has brought new problems of universal interest which we have scarcely begun to analyze. They embrace such questions as the meaning and tendency of race conflicts, the control of the tropics, the attitude of imperial nations toward subject races, the best forms of colonial administration. So far as our political economy is concerned Japan is as much a part of the United States as Oregon; Matabeleland is the next door neighbor of Saskatchewan; the spirit of war in the bosom of the Herrero tribesmen makes the issue for an imperial election in Germany. The shuttle of trade and intercourse flies ever faster and it may be weaving the web for a world state. It may be that steam and electricity are to achieve what neither the armies, nor the law, nor the faith of Rome could accomplish—that unity of mankind which rests on the expansion of a common consciousness of rights and wrongs through the extension of identical modes of economic activity.

In closing this lecture, it seems desirable that I should indicate more precisely some of the tendencies in the scientific literature of politics. In comparing the political writings of the last twenty-five years with earlier treatises one is struck with decreasing reference to the doctrine of natural rights as a basis for political practice. The work of Mr. Ritchie in demonstrating that natural rights are at bottom only moral aspirations has been effective. The

theory has been rejected for the reason that it really furnishes no guide to the problems of our time and because we have come to recognize since Darwin's day that the nature of things, once supposed to be eternal, is itself a stream of tendency.

Along with the decreasing references to natural rights there has gone an increasing hesitation to ascribe political events to Providential causes. In older states where the theory of the divine kingship predominated, where the affairs of government were conducted with great pomp and ceremony, writers spoke with considerable confidence of divine interposition in political events, but in our time scholars find it scarcely in keeping with the dignity of their science to ascribe the outcome of a caucus or lobby to the same source. As in history, scholars are seeking natural and approximate causes; they treat politics as a branch of sociology; and leave to the theologian and philosopher the ascertainment of the ultimate rationale of the whole complex.

Closely related in spirit to the tendency to elucidate political questions by reference to divine will was the somewhat later notion that divergences in the history and institutions of different peoples were to be explained on the ground of racial characteristics. For example, the quiet democratic revolution of England in the nineteenth century is attributed to the superior genius of the Anglo-Saxon people, while the many revolutions in France are to be explained by the fickleness and waywardness of the Gallic mind. This is very comforting to the scholars of one of these two nations, but it overlooks the fact that the English people established constitutional government in the seventeenth century by a process analogous to that required in France, that is, by seven years of civil war, the execution of the king, experiments in all sorts of fantastic democracies, military dictatorship, wars of conquest,

restoration and adoration of the monarch, and finally another revolution. It is a curious and illuminating fact that Torcy, Louis XIV's minister, in comparing the stability of the French monarchy with the vicissitudes of the Stuarts, came to the conclusion that the Englishman was at that time organically incapable of decent political conduct. Now, it is not to be denied that there are such things as race characteristics, but as Seeley warns us "we should be slow to allege mere national character in explanation of great historical phenomena. No explanation is so obvious or suggests itself so easily. No explanation is so vague, cheap, and so difficult to verify. Why did the English gain freedom so early? Anyone can answer, because they are English and it is the nature of Englishmen to love liberty. I call this a cheap explanation. It is easily given and almost impossible to verify. It is the more suspicious because it gratifies national vanity." Wherever Hegel, with his *Patriotismus* reduced to a science, has been dethroned there is a decided tendency to look to economic and material facts rather than to race psychology as the most reliable sources of institutional differences.

The practical outcome of this rejection of the divine and racial theory of institutions is a persistent attempt to get more precise notions about causation in politics, and this is destined to have a high practical value. The heat with which the politicians cite the fate of the Roman empire as evidence of what will happen to the United States if the Philippines are retained; the light-heartedness with which legislatures undertake sweeping enactments without realization of direct and indirect results; and a thousand experiences of political life bear witness that a treatise on causation in politics would be the most welcome contribution which a scholar of scientific training and temper could make.

After all I have said about the fields of political research and the intensely human and practical nature of the questions which students of politics have to consider, it may seem a work of supererogation to refer to the actual service of the science of the nation. Nevertheless, I believe a word of defence should be spoken, for in this world of ours we are turning keen and troubled faces to the instant need of things, and it is wise that we should. Decidedly real as are the subjects with which the student of politics deals, it must be admitted that he suffers many disadvantages when he endeavors to meet the call for practical receipts guaranteed to cure quickly. The nation as a whole is a high abstraction; it seldom demands remedies; it is groups within the state that demand remedies. Shipbuilders want ship subsidies; workingmen want labor legislation. The desirability of their demands cannot be referred to eternal standards; what they will probably get will depend more on the power and effectiveness of their organization than upon sweet political reasonableness. If the student of politics prescribes a remedy which pleases the group that applies, he will probably be hailed as a scientist; if his suggestion is unpalatable, he is only a professor anyhow.

Notwithstanding this fact, politics renders a high service in general and in details. Statesmen have gained in breadth and firmness of perspective in proportion as they have deliberated upon one or all of the great subjects which fall within the domain of politics. The origin, tendencies, and destiny of human society politically organized are subjects, moreover, which appeal to the highest type of a citizen. The ideals arising from the contemplation of experience and the potentialities of the future, more than anything else differentiate human from animal societies. Mature consideration of the problems of state in the grand outlines helps to transform petty politicians into statesmen, and inspires them to press on even when in the midst

of party squabbles they lament with Machiavelli the "fickleness and folly of a vain world." The discipline that comes from deliberating upon great things, even though we see through the glass darkly, has a real value though it cannot be weighed in scales or sold over the counter.

To speak more modestly of politics, I shall descend into particulars. Politics renders a service by the collection and classification of data, by the description of institutions and experiments, and this service alone justifies it in claiming a high place in the university. On a question of primary reform, to illustrate by a single example, it is the business of politics to discover and arrange the best literature on the subject, to classify the types of legal control adopted in various states, and to marshal such information as may be available on the actual operation of these various types of control. The recent sane tendencies of legislative bodies to construct laws on reports of expert commissions rather than on impulse and high notions of popular prerogative, however legitimate, is only an application of the scientific method and spirit of politics as a university subject. Such action is not infallible, but surely we may agree with Diderot that the use of such reason as we have is not indecent. As I view it, accordingly, it is the function of the university research in politics to seek the truth concerning special problems simply in the spirit of science.

It is the duty of the teacher to say to his pupils: Observe these facts, consider these varying explanations, ponder upon these theories, study the most impartial records of political operations, look to the future as well as the past, and as a citizen of this great nation build this discipline of the mind into the thought and action of after life. Book-learning cannot make a wise man of a fool nor a great statesman out of a village politician; it cannot correct nature's mistakes, but it may open highways to her potentialities. Technical information is the necessary part of the

equipment of the person who intends entering the actual service of the state, and the wisdom that comes from a wide and deep and sympathetic study of the political experiences of men is the true foundation of that invisible government, described by Ruskin, which wears no outward trappings of law, diplomacy, or war, but is exercised by all energetic and intelligent persons, each in his own sphere, regulating the inner will and secret ways of the people, essentially forming its character and preparing its fate.

JURISPRUDENCE

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
FEBRUARY 19, 1908**



JURISPRUDENCE

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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published May, 1908.

JURISPRUDENCE

Our lives are controlled, to an extent which we do not measure without effort, by rules of conduct which are imposed upon us by our environment and which we may not contravene without endangering our existence, our welfare or our happiness. We do not ordinarily realize the multiplicity of these rules or their coercive operation, because our acceptance of them is largely unconscious and our obedience to them, the leading of a normal or regular life, is largely automatic. When, however, we force ourselves to consider all these rules, and when we attempt to classify them, we see that some of them, such as the rules of healthful living, represent primarily the adaptation of our conduct to our physical environment; others, such as the rules of thrift, adaptation to what may conveniently be termed our physical-social environment, that is, to those conditions which result from the interaction and reciprocal modification of human society and its environment; while a third group of rules, which may be termed social, seems to be imposed upon us by the sentiments or the will of our fellow-men. When rules which we assign to the physical or to the physical-social group appear also, as they often do, in the distinctively social group—when, for example, we find that violations of the rules of health or of thrift are denounced as immoral and are in some instances penalized by law—it still remains true that these rules are not primarily social. They do not originate in social opinion, and disregard of

them is attended by risks which society has not created. They receive the additional sanctions of morals and of law because human interests are so solidary that the individual cannot live or die or prosper or suffer for himself alone.

It may of course be queried whether we have any right to consider human society as a thing distinct from its physical environment, acting independently upon that environment and imposing upon us, as individuals, rules of conduct which are purely social. In the constitution of human society, indeed, there is much that seems arbitrary, and in its action there is much that is incalculable; but it is possible that our inability to forecast social action is due solely to the complexity of the phenomena, and that our impression that society determines in any degree its own constitution and conduct is an illusion. These questions, however, lie outside of the field of jurisprudence. The law with which our science has to do assumes the existence of individual wills and bases its authority upon a social will. Whether the individual will is in any sense free; whether the social will is the resultant of free individual wills or a direct and independent product of the social life; in what degree the social life is itself controlled by forces which men do not create and cannot control—these are questions which the jurist gladly leaves to the psychologist, the sociologist and the philosopher.

Legal rules, even when they are assignable, by virtue of their origin, to the physical or to the physical-social group, belong, as regards their legal quality, in the group of social rules. In the same group we find a second body of rules which we call moral; and in addition to legal rules and moral rules we are aware of a third body of more or less heterogeneous rules which you will permit me, for convenience, to call manners.

What now is the characteristic which differentiates law from manners and morals? Obviously not the field in

which it operates, not the matters with which it deals. Law has indeed a field, or a number of fields, in which it operates alone. Law has created institutions of its own; and the rules which shape these institutions and govern their operation had no previous existence in manners or in morals. To a large extent, however, manners, morals and law cover the same field. To knock a man down, for example, or to wrest from him portable valuables is, in most instances, at once unmannerly, immoral and illegal. Especially large is the field which is common to law and to morals—so large, indeed, that many time-honored definitions of law assume a complete correspondence of law with morals, and it has been possible to say, although erroneously, that law is simply applied morals.

It is equally impossible to find the distinguishing characteristic of law in its purpose or end. The primary purpose of law is the maintenance of the social order; but this purpose is also subserved, in large measure, by morals and by manners. The graver disturbances of the established social order are usually stigmatized as immoral. The existence, in the various fields of human effort, of accepted and regular modes of activity does much to lessen the friction of social life; and the established forms of social intercourse, manners in the narrowest sense of the word, take out of the struggle for existence much of its bitterness and perhaps do more than either morals or law to prevent breaches of the peace.

The ultimate purpose of the law, indeed, is not the maintenance of the social order but the assurance of the conditions of social progress. That man shall obtain increasing control over his physical environment; that the relations of men shall become more and more kindly; that human life shall be more and more worth living—these are the final objects of the law. To attain these ends individual effort must not only remain worth while, it must be increasingly

encouraged; in other words, competition must continue; and yet anti-social activities must be increasingly restrained and there must be increasing coöperation. The fundamental and eternal problem of human civilization is the reconciliation of individual with social interests. Such progress as has thus far been made towards the solution of this problem has been achieved by raising the plane of competition and by increasing the range of coöperation. In the methods of competition craft has replaced brute force, and fair play is replacing craft. The objects of competition have become and are becoming less and less material: honor is sought rather than wealth, and higher honor is accorded for social service than for personal success. The coöperation of the horde has been replaced by that of the class and, in many fields, by that of the nation; international coöperation exists and is increasing. All these ends, however, are moral as well as legal ends, and higher ethical ideals indicate lines of legal progress.

We gain our first glimpse of the distinguishing characteristic of law, and perhaps of that of morals also, when we note the different results that attach to the disregard or violation of different rules of social conduct. If the rule infringed be one of manners simply, there is usually a social reaction of surprise, attended commonly by ridicule of the offender. If the rule infringed be one of morals, the social reaction is more energetic: it is more than a surprise, it is a shock, and it is attended by more or less heated disapproval, which may range from contempt through scorn to loathing. In the mind of the offender himself there is a reflex of the social disapproval; there is the prick of conscience, the sense of shame; and if he be a religious man and his offense be one that his religion brands as a sin, there will be a sense of divine displeasure. Arnold defined religion as morality touched with emotion; but there is a marked element of emotion in morality itself, independent of

religion. All these reactions, it will be noted, are purely psychical, and the penalties which follow breaches of manners and morals operate upon the offender's feelings. Law, on the other hand, encourages certain courses of conduct by the assurance of advantages and discourages other courses of conduct by imposing disadvantages or penalties which affect the property or the person; and these purely legal consequences may be enforced, in case of need, by the entire physical power of the community.

We note further, and this brings us to a second *differentia* of law, that the advantages which follow the observance of legal rules and the disadvantages or penalties which attend the disregard or violation of such rules do not attach solely by virtue of the social sentiment or opinion, but by virtue of the social will. In civilized communities this social will is formulated through special processes and usually by special organs. The processes are mainly political and the organs are for the most part governmental. In constitutions adopted by the people, in acts passed by representative bodies, in orders of administrative officers and in decisions of courts we find, authoritatively stated, the rules of law, the advantages which attach to their observance, the disadvantages or penalties which follow their disregard or violation. The rules of manners and of morals, on the other hand, are not stated in any such authoritative form. In early society, indeed, authority over the entire field of conduct is usually accorded to priests, and in later stages of social development this authority frequently persists in the field of morals; but in an advanced civilization it tends to disappear. It may still be asserted, and it may long command extensive recognition; but the recognition becomes less and less general, and morals, like manners, tend to rest directly upon social sentiment and opinion. They are matters of usage.

To affirm that law is formulated through special processes, and chiefly by special organs of the community, is not to deny that its rules are largely determined by social sentiment. Manners and morals are, to a large extent, antecedent to law, and social usage has always furnished much of the material of which law has been made. In the earliest stages of legal development usage apparently furnishes all the material; it is converted into law simply by adding the support of social force; and in every state of social progress new law is made by the recognition and enforcement of established customs. Manners, morals and law, all appear to rest ultimately upon social utility. The conversion of usage into law, the decision whether any particular rule of conduct shall be supported by the physical power of the community, is clearly a question of social expediency. Social utility or expediency is determined, in the whole field of conduct, by the social judgment, and social force can be exercised only by virtue of the social will. The social judgment, however, is usually inarticulate; it reveals itself as sentiment. In the matters with which the law deals, we call this sentiment the sense of justice. The social will, likewise, is, in most instances, not aimless indeed, but only vaguely aware of its true aim; it manifests itself as impulse to do something, to sweep aside or crush something that is felt to be alien and hostile. As it is the primary function of practical ethics to interpret moral emotion and to give articulate form to the moral sentiment, so it is the primary function of practical jurisprudence to interpret the sense of justice and to formulate in legal rules those ends toward which the social will is blindly groping. Ulpian's "*nomen iuris a iustitia*," although indefensible from the philological point of view, is good philosophy. In the interpretation of the social sentiment and the social will judges and legislatures have indeed an authority which no men or bodies of men possess in the fields of manners and

morals: even when they misinterpret the general sense of justice and thwart the general will, the rules which they lay down are law. Such law, however, has no root, and, if it be not formally abrogated or superseded, it becomes a dead letter. In the long run, general sentiment and opinion control not only the finding and making of law, but also its enforcement.

Persistent disregard of general sentiment on the part of lawfinders or lawmakers is exceptional; in the democratic state it is almost impossible. Conflicts between general sentiment and positive law arise, as a rule, only when social changes have made the established legal rules unsatisfactory. Such conflicts take the form of agitation for the reform of the law, and they cease when the law is suitably amended. Conflicts between sectional or local or class sentiment and the general law arise, on the contrary, in every type of state, and such conflicts are practically incessant. Powerless, as a rule, to control lawfinding or lawmaking, adverse minority sentiment makes itself felt in resistance to the enforcement of the law; and under favoring circumstances the resistance may result in the nullification of the law. From such results it is sometimes inferred that the physical sanctions of the law are less coercive than the psychological sanction of opinion, even when the opinion is that of a portion of the community only, of a locality or of a social group. It should be noted, however, that when the law is worsted in these conflicts it does not put forth its full power. It is defeated because it binds its own hands. Laws are nullified, for example, because local administrative authorities are legally independent of the central administration, or because juries are permitted by the law to interpret the law as they see fit. It may not be advisable to destroy or seriously to limit local self-government because Sunday-closing laws are locally nullified, or to empower judges to set aside verdicts in criminal cases because busi-

ness or labor interests make it difficult to punish illegal combinations; but these or similar changes in the law can be made if such be the general will.

The strength of the law lies in the fact that its physical sanctions operate, or can be made to operate, with equal force throughout the entire area of a state and among all classes. The weakness of general opinion lies in the fact that it operates less strongly on men's minds than does the opinion of their locality and that of their class. Especially strong is the influence of group opinion, and it is strongest in the smallest and most homogeneous groups. The pressure of social opinion seems to vary inversely as the square of the social distance. Hence the tendency of all usage to variation and to particularism; hence the lusty growth, at all times, of group morals—morals of the class, of the profession, of the business, of the gang. Left to itself, enforcing itself only by the pressure of social opinion, our existing morality would tend to revert to its primitive form, the usage of the horde. The higher social utilities which the rules of general morals represent could never have prevailed over the interests of the horde or of the tribe or of the class through any appeal to reason or to individual interest; for feeling is stronger than reason and group feeling is stronger than self-interest. The agencies which in the past have slowly subordinated group morals to general morals, and by which general morals were perhaps first formulated, are religion and law. Every religion that has developed beyond the stage of a clan cult has, on the whole, lent its psychical sanction to the more general morals; and the religious sanction, like the legal, can be made to operate with equal force over indefinite areas and upon all social classes. The law, in so far as it has had to deal with moral questions, has likewise put its special sanction, that of physical force, behind general morals. In the early stages of civilization, religion apparently played the more im-

portant part in formulating the rules of general morals and in securing their triumph; in later periods and at the present time law has possibly become the more efficient agency. Religion influences the believer only; law coerces even the anarchist. Confessions are divided into sects, and churches are organized, in some instances, along the lines of class cleavage; states grow larger by conquest or by federation, and modern states are becoming increasingly democratic.

Our analysis of social rules and of their operation upon the individual is not complete without a word regarding constraints that are neither purely psychical nor purely physical but economic. A religious association, possessing at the outset no means of securing obedience except those which are purely psychical, may come to exercise so general an influence over the minds of men that individuals cast out from its communion are completely boycotted and can obtain none of the necessities of life. A relatively small number of persons, united by ties of class interest, may so monopolize land or other means of production that no one can live by his labor except upon the terms which the group prescribes. A larger number of persons, similarly united by the ties of class interest, may so monopolize the labor market that no one outside of their association can obtain regular employment and that the production of goods becomes impossible except upon the terms which they dictate. There have been periods in which such associations or groups have become states, or at least governments. This was the case in the middle ages with the Christian church, the feudal nobility and some of the city guilds; and the rules established by these associations became law in the strictest sense of the word, since they were generally accepted and were supported by physical force. In the democratic state, however, with monarchic or representative government, such associations are not permitted to exercise

permanently an economic constraint which parallels and possibly neutralizes the constraints imposed by the general will and applied through governmental organs. If the ends which such associations pursue are approved by the social judgment, the constraints are legalized, but the associations are brought under legal control. Otherwise, their efforts to exercise an irresistible extra-legal constraint are repressed as illegal conspiracies. The democratic state is rightly jealous of its monopoly of coercion, for its government alone can be trusted to exercise coercion in the interests of liberty.

By way of summing up the results thus far reached, I suggest, with all deference to the superior authority of the specialists in ethics, that morals is that part of the social order which is supported by social opinion, touched with more or less emotion; and, with more confidence, I describe law as that part of the social order which by virtue of the social will may be supported by physical force.

Law is in part found, in part made; that is, it is established partly by decisions and partly by legislation. Of these processes the decision is not only the older but the more important and the more persistent. A decision is not alone the termination of a pending controversy, it is also a precedent for future decisions. To us, to-day, the word suggests primarily a judicial decision; but there were decisions before there were courts, and decisions that make law are still rendered to-day outside of the courts. The primitive human community resembles those lowest forms of animal life which exercise with the whole body a number of functions which the higher animals exercise only through special organs. The primitive decision is a community-decision, and its earliest form is the lynching or running-out of the individual who has violated one of the rules of conduct which the community feels to be funda-

mental. In somewhat more advanced communities there is another very important form of community-decision. When a man has slain another in self-defence or in rightful vengeance, the community may intervene to protect him from blood-feud, just as to-day the community, acting through special organs, absolves from responsibility the individual who has shot a burglar at night in his bedroom. In both cases the slaying of the wrongdoer precedes the decision that he has been rightfully slain; but in both cases the decision in favor of the man who has taken the law into his own hands recognizes that what he has taken into his own hands is law.

After the establishment of courts, community-decisions tend to disappear in that part of the law with which the courts are competent to deal. In those parts of the law, however, in which the courts are not competent, in political law, for example, community-decisions have continued to establish law in modern times. All unwritten constitutions rest on precedents, and constitutional precedents are set whenever acts of power are supported or accepted by the whole community. And in the international community the only rules that are strictly legal are those which have been enforced in the past, and will therefore presumably be enforced in the future, by the international community, the concert of powers. The rest of what we call international law is as yet only international morals and manners.

The processes by which early society develops judicial and legislative organization have only recently begun to be understood. As regards European communities, we can now say with confidence that neither lawfinding nor lawmaking has any historical connection with the authority of a patriarch to settle disputes of his descendants and to lay down rules for their future conduct. In general, it may be said that the more light we get on the conditions prevailing in really primitive human society, the less we see

of anything resembling a patriarch. Ages seem to have been necessary for the establishment of marital and paternal authority, and ages more for the development of the patriarch; nor is any patriarchate so complete as that of the Romans known to have existed among any other European people. The earliest European court was not patriarchal but popular. In it the community still acted collectively, but it acted not as a mob but as an orderly assembly. The assembly court had from the outset special lawfinding organs; it gradually developed special organs of decision; and the modification, rearrangement or combination of those organs have produced every type of modern court.

Legislation, as we know it, has two historical roots: formal agreement of the community (which originally, it seems, had to be unanimous) and the order issued by the war-lord to the people under arms. From the power of the military leader to issue orders to his men was derived, when temporary leadership grew into permanent kingship, the power to issue orders in time of peace. Among European peoples, however, such orders were not originally regarded as laws in any proper sense, but merely as administrative measures; and neither among the Germans nor among the Romans could such orders be enforced, originally, by any means other than a fine, legally limited in amount. Only in proportion as a king gained power by conquest did his ordinance power expand into anything like legislative power; and it amounted to general legislative power only when the king became an absolute monarch. In the modern state the executive order has shrunk into something like its original dimensions, while the general power of the people to legislate by agreement is still exercised directly or through representatives.

Even in the earliest stages of legal development, when the social will manifests itself directly in social action—in

lynchings, for example—there are experts to tell the community why it acts as it does. These experts are not lawyers only; they belong to the single undifferentiated profession from which have emerged all the professions of civilized life; they are experts in all matters natural, human and divine; they formulate the rules of health, of thrift, of manners and of morals. All this knowledge is one body of wisdom, and all these rules are part of the religion of which these men are the priests. In their undifferentiated activity we are nevertheless able to recognize special fields of legal action. They define not only the cases in which individuals may rightly be slain or be thrust out into the deserts or forests, but also the cases in which clan feud may be rightly raised or private vengeance rightly taken. They also devise the earliest methods of deciding doubtful cases and of terminating controversy. Among the early Romans the legal activity of the priests had become so highly specialized that not only was there a class of priests whose business was chiefly legal, but there were three boards of these priests: one for interstate relations, another for the public law of Rome, and a third for the private law.

After courts of justice were established, the priestly lawfinder was succeeded and displaced, in European legal development, by the secular lawfinder, whom the Romans described as the jurispudent or jurisconsult, the Germans as the wiseman or lawspeaker. These lawfinders were unofficial persons: they were neither elected by the assembly nor appointed by king or magistrate. They emerged from the body of the people by a natural selection; they were entitled to declare the law because they knew the law. Conclusive, of course, as to the authority of a new lawspeaker was the general opinion of the older and recognized lawspeakers. These experts were not judges in our sense, nor did they directly decide controversies. In the early Euro-

pean court a governmental chairman heard the pleadings of the parties, but he was not necessarily a lawyer. The decision was rendered originally by the whole body of the freemen, as among the Germans; in a more advanced stage of development it was rendered, as in Greece and republican Rome, by a larger or smaller body of citizens, or by a single citizen; but even when, as at Rome, the decision on the law and the facts was rendered by a single citizen, he was not necessarily learned in the law. The naturally selected unofficial experts informed the chairman of the court whether the pleadings were regular; and it was from such experts that the people or their representatives learned the rules of law which should govern their decisions. Outside of court these experts gave legal advice to individuals. They accordingly combined the functions of the modern lawfinding judge and of the modern counselor.

The modern type of court with which we are all familiar was constructed at Rome in the early Empire, and was constructed again a thousand years later in Norman England, by the simple expedient of selecting a jurist or wiseman for chairman of the court. This change substituted for the naturally selected unofficial lawfinder an artificially selected official lawfinder. In the English type of court popular coöperation in the administration of justice reappears in the jury; but, as the decision of the people in the earliest European court was guided by the instruction of the expert, so the decision of the modern jury is guided by the learned judge.

After the judges were taken out of the general body of experts, the remainder of the legal profession (including certain elements which were not historically derived from the lawspeaking or jurist class) was organized either, as in England, in the two groups of barristers and solicitors or, as in imperial Rome and in the United States, in a single undifferentiated body of practising lawyers.

When we say that law is established by decisions, we do not mean that the condemnation or acquittal of a person accused of crime or the rendering of a judgment for the plaintiff or for the defendant in a civil case establishes the law. It is in the determination of the legal question at issue, by the recognition and formulation of the legal rule which governs the case, that the law is established. This, as we have seen, has always been the work of experts. That part of the law which the Romans described as the customary or unwritten law, which we describe as common law or case-law, is, in reality, simply expert opinion. The unwritten law of Rome consisted, in the republican period, of the "responses" of the unofficial jurists, in the imperial period of the responses of the jurists who were authorized to respond and who, for the most part, were imperial judges. Old German tribal law was found in the "wisdoms" or "dooms" of the wisemen or lawspeakers; English and American common law consists of the opinions rendered in court by learned judges.

These experts, it should be noted, have always been men engaged in the practical application of the law; and their opinions have always been given in connection with cases actually in litigation and in view of the facts of each special case. It should be noted, further, that the unsupported opinions of single experts have rarely been regarded as authoritative. The response of the single jurist at Rome, the wisdom of the single lawspeaker among the Germans, was regarded as establishing the law only in so far as it was accepted by the whole body of legal experts. Similarly, in the latest stage of legal development, the opinions which are cited as authoritative are those rendered on appeal by courts of final instance. It should be added that the modern bench always depends largely on the bar to cast light on all sides of a difficult legal question, and that, in the English and American practice, the authority

of a decided case may always be impugned on the ground that it was not fully argued. To make our description of unwritten or case-law completely accurate, we should therefore say that it is deliberate and accordant expert opinion.

While the expert lawfinders have always claimed that they were following precedents and abiding by the rules laid down in decided cases, they have always exercised great freedom in the interpretation of earlier decisions. In the development of the customary or unwritten law it has always been assumed that the law which is found in decided cases existed somewhere before the cases were decided. One of the oldest German words for law is *etwa*, that which has always been. Of this eternal law the wisdom or dooms pronounced by the wisemen were simply the accepted statements. This is still the orthodox doctrine of all courts of justice. From it is derived the very important inference that the form in which a rule has been stated in earlier cases is not binding; it is always admissible to re-examine the cases and to restate the rule. The possibilities of change and development inherent in such a theory are obviously very great; they have been sufficient to enable the courts to meet, by constant re-interpretation, most of the needs of a progressive society. It was in fact mainly by interpretation that the Roman law and the English law were developed from rude customs into the stately fabrics beneath whose shelter all civilized peoples except the Chinese and the Mohammedans are now living.

In connection with the development of the rules of the unwritten law there also gradually appears a set of more general rules described as principles. These present themselves as propositions of which the ordinary rules are merely corollaries; and from these principles are frequently derived, in case of need, entirely new rules. The eternal existence of these principles is asserted with even greater

energy and persistence than is the eternal existence of the special rules; but here also it is recognized that no particular statement of a principle is definitive.

When we make abstraction from the time-honored fictions of the lawfinders, and consider what European legal experts, priests, lawspeakers and judges have actually been doing in the twenty-three hundred years over which our observation extends, it is impossible, I think, to deny that their methods have been scientific—far more scientific than their own description of their methods. The fundamental assumptions upon which all their work has been based are obviously these: that law exists for the protection of social interests, and that social interests are more truly reflected in social feeling, in the general sense of justice, than in any reasoned theories. In their effort to give to the social sense of justice articulate expression in rules and in principles, the method of the lawfinding experts has always been experimental. The rules and principles of case-law have never been treated as final truths but as working hypotheses, continually retested in those great laboratories of the law, the courts of justice. Every new case is an experiment; and if the accepted rule which seems applicable yields a result which is felt to be unjust, the rule is reconsidered. It may not be modified at once, for the attempt to do absolute justice in every single case would make the development and maintenance of general rules impossible; but if a rule continues to work injustice, it will eventually be reformulated. The principles themselves are continually retested; for if the rules derived from a principle do not work well, the principle itself must ultimately be re-examined.

The further this process is carried, the more does the conscious recognition of social utility become the real, although unavowed, basis of decisions—"the secret root," as Holmes says in his *Common Law*, "from which the law

draws all the juices of life." In novel cases, however, especially when their novelty is due to changed social conditions—in cases, that is, in which the sense of social utility has not yet attained its reasoned justification—the finding of new law is always controlled by feeling rather than by reason.

That legal experts have not generally described their methods as experimental and inductive is probably due to the fact that the scientific character of such methods has not been generally recognized until modern times. Through the ages in which deduction from unquestioned premises was regarded as the only scientific mode of thought, the lawyers not unnaturally endeavored to represent their premises as absolute and unchanging and their method as purely deductive.

Great as are the possibilities of the development, by interpretation, of law which has no objective existence except in its interpretation, these possibilities are not unlimited. In all law, and most of all in law established by decisions, there is a tendency to persistence, a resistance to change. This is true of all law, because society demands not only that the rules of law be just, but also that they be certain. It is especially true of case-law, because the development of this law is wholly in the hands of lawyers, who are generally more conservative than laymen. Their conservatism is rational, because they understand, better than laymen, the meaning and the value of the accepted principles and rules of the unwritten law; and it is valuable to society, because these principles and rules represent the abiding sense of justice, as against momentary gusts of popular feeling, and the accumulated experience of centuries, as against impressions derived from situations which are exceptional and which may be transitory. Legal conservatism, however, is a constant impediment to necessary

changes; if it cannot prevent, it delays them; and the delay which it causes is most constant in case-law. A current of decisions may be diverted, but it cannot well be made to flow backward; and if its direction is to be seriously modified, it will not turn abruptly but will sweep round slowly in a very long curve. Accordingly, in periods of rapid social change, law is made by other processes than those which we have been considering.

One of these processes is that by which the prætorian law was developed at Rome and equity in England. In both instances new law was made and enforced by executive or administrative authority, and in both instances this new law was developed experimentally in the administration of justice between litigants. It was thus substantially the same process by which the older law had been developed; but the old precedents were disregarded and a fresh start was made. Both at Rome and in England the new law was framed by experts: at Rome by the jurists who sat in the councils of the prætors, in England by a special court with its own bar. In both instances admirable results were achieved; but in both instances the production of new law through these administrative agencies ceased when the social needs which had set them in motion were satisfied. The prætors and chancellors began to adhere with increasing strictness to the precedents established by their predecessors; the new law became relatively stable; and the ensuing legal development proceeded along the old lines of interpretation until legislation became active.

In modern times, however, the making of law by the decisions of administrative authorities is reappearing. On the continent of Europe there are regular administrative courts, and their decisions not only control the working of the administrative machinery, but affect the interests of individuals. In our country administrative tribunals are multiplying in the form of federal and state commissions,

which are clothed with quasi-judicial as well as with quasi-legislative powers and which are meeting new social exigencies by decisions as well as by administrative orders. When, as is the case both in Europe and in the United States, certain matters fall exclusively within the jurisdiction of these administrative authorities, their decisions create new law. In Europe it is recognized that administrative judges should be experts alike in administration and in law. In the United States, where administrative tribunals are comparatively new and their importance is imperfectly realized, this double qualification is not as yet demanded.

Legislation is confined, in early stages of legal development, to matters of policy and is chiefly employed for the adoption of temporary measures in the face of special exigencies. The abiding social order, the ancient law, is too sacred a thing to be changed consciously and openly. When early legislation touches the field of general law it is usually declaratory, that is, it simply affirms the law already recognized and enforced in the decision of controversies. Such declaratory legislation first appears, in many communities, in connection with early attempts to set forth the law as a whole, that its provisions may be better known. The use of legislation, whether popular, royal or representative, as a means of changing the general law comes late in European political life. The idea that the law stands in need of constant change and that the necessary changes are normally to be accomplished by legislation is an idea that appears only in a very advanced civilization. In the Roman Empire it appeared only in the period of decline and decay. In the West Gothic and Frankish Empires legislation was fairly frequent because of the persistence of late Roman traditions. In mediæval Europe, after the ninth century, there was little legislation except in church councils and in the free cities; and in the

cities legislation was active only when they had attained a high degree of economic and political development. In the modern European states there was little reformatory legislation before the eighteenth century, nor did statutory law gain anything like its modern volume before the nineteenth century.

The increasing part played by legislation in late periods of legal development is due in some measure to the increased rapidity of social change, in some measure to an exaggerated faith in the power of law to modify social conditions and to remedy social evils, but in the main, apparently, to the fact that there are certain portions of the law which courts are wholly unable to develop and certain other portions in which judge-made law is less satisfactory than enacted law. Political law, constitutional and administrative, is usually beyond the competence of courts. This part of the law, developed during long stretches of time by community-decisions, is at last embodied in statutes and in written constitutions. Again, that part of the law which expresses interests which are primarily social tends always, and particularly in a democratic society, to be formulated by the direct assertion of the general will. Finally, there is a considerable part of the law which is distinctly arbitrary. Here also there must be rules; but from the point of view of justice it seems immaterial what the rules shall be. Here certainty, not justice, is the imperative social demand, and here the movement toward legislation begins at a very early period.

After ceding all these fields to legislation, a large domain may yet be reserved for the tentative development of law by the courts. To the courts may be left that part of the law which primarily subserves the interests of individuals, which accordingly grants to individuals a large measure of liberty, and which, for this reason, has to deal with extremely varied and highly complex relations. In

this part of the law the demand for justice is more imperative than the demand for certainty. This part of the law, roughly speaking, is the law of personal property, of contracts and of torts. To the very end of the Roman Empire this part of the law remained embodied in decided cases, and the same is true to-day among all English-speaking peoples. The belief, so generally held to-day, that in a really advanced civilization legislation must cover the whole field of the law, that the finding of law by courts is a remnant of archaic conditions destined gradually to disappear—this belief has no basis except in the conditions existing to-day in continental Europe and in those countries which have derived their institutions from continental Europe. But in continental Europe, from the dissolution of the Frankish Empire until the establishment of national states, the political and legal development was abnormal. In the Roman Empire, and in England after the Norman conquest, there were at all times organs capable of finding general law as well as organs capable of making such law, and there was always a central authority able to subordinate local law to general law. Both in the Roman and in the English legal development, accordingly, it was possible to create general or common law by decisions as well as by legislation. In continental Europe the national state developed much later than in England: in Germany and in Italy it was not organized until the nineteenth century. Until it was organized there were no efficient organs for finding or making national law. When it was organized, the existing law was in the main provincial or local; and the provincial and local laws were so firmly established that national law could be produced only by legislation, and a complete body of national law could be created only by codification.

The work of the legislator is akin to the work of the judge, in that it is his business to express the social will in

the form of rules. In the work of the legislator a higher degree of skill is required than in the work of the courts, because rules laid down in statutes are less easily amended than rules laid down in decisions. A representative legislature, in particular, is a cumbrous piece of political machinery, not easily set in motion; and if a law be ill-considered or badly drawn, it will do much harm before it arouses enough resentment to secure its amendment or repeal. In modern European countries, including Great Britain, these considerations have led to the development of a class of legislative experts, men who are primarily trained lawyers but who are also trained legal draftsmen, and who hold permanent appointments in the governmental service. These experts not only draw all bills which are introduced by the government, but they examine bills introduced by private members of the legislative body; and it is usually impossible for a private member to secure the adoption of a bill unless it be put in such form as the governmental experts deem satisfactory. Under the influence of this body of legislative experts, a scientific theory of legislation has obtained general acceptance. It is recognized that no finite intelligence can anticipate the various situations to which a proposed law may become applicable or the varying conditions under which it may be applied. A modern European statute accordingly lays down the principles that are to be applied or indicates the ends that are to be attained, and leaves the detailed rules which shall give effect to the legislative purpose to be formulated in administrative orders or to be worked out in decisions. In the United States the legislative expert is only beginning to appear and is still in the unofficial stage of development. Under these conditions it is not surprising that our theory of legislation is that of a past age. Our legislators try to do too much, and by attempting to provide for all contingencies they not only embarrass the

administration and the courts, but in many cases they defeat their own purposes.

The making of a code, especially of a civil code, which sets forth the rules of the private law, that is, the law of property, of contracts, of family and of inheritance, is the most difficult work in the field of legal science. The successful solution of this problem presupposes a large and well reasoned body of case-law and numerous well digested systematic treatises. No single expert has ever constructed a satisfactory civil code: the work must be done, as it has been done in modern European states, by a commission of experts. The most scientific process which has ever been employed in the work of codification is that which was employed in the German Empire in the construction of the existing civil code. A committee on plan and method was appointed in the spring of 1874. In the autumn of the same year, in accordance with the recommendation of this first committee, a commission of eleven eminent jurists was constituted, with the chief justice of the highest imperial court as its president. In the year 1887 a complete first draft was presented to the government. In 1888 this was published, with five volumes of "motives." An enormous amount of expert criticism appeared in this and the ensuing years. All this criticism was carefully digested by governmental experts. Their digest was arranged in the order of the sections of the draft code and was published in 1894. With the aid of this digest a second commission revised the draft of 1887, and a greatly improved second draft was published in 1895. After further slight revision by a committee of the Imperial Diet, the code was adopted in 1896, and it went into force in 1900.

The occupation of any portion of the legal field by written law, constitutional or statutory, in no wise terminates the activity of the courts in that field; it does not even ter-

minate their lawfinding power. Scientific legislation recognizes fully that the detailed rules which are needed to give effect to a legislative policy must be worked out partly or wholly by the courts. Unscientific legislation requires from the courts something more than this subsidiary lawfinding; it requires corrective interpretation. The same is true of the most thoroughly considered and most carefully drawn laws, when the social conditions to which they must be applied have undergone serious changes. According to the theory of the separation of powers, the courts should not use their power of interpretation for the purpose of correcting or amending legislation; they should apply the written law as it is written, leaving to the legislatures the task of improving it. Practically, however, this course would result in so much inconvenience and injustice as to arouse public resentment, not against the legislatures but against the courts. The general purpose of the law, it would be said, is evident; why do the courts not endeavor to realize that purpose? This accordingly is what the courts try to do. For more than two thousand years it has been an accepted legal principle that, in interpreting the written law, effect should be given, as far as possible, to the spirit and intent of the law. Here again the possibilities of lawfinding under cover of interpretation are very great. A distinguished German jurist, Windscheid, has remarked that in interpreting legislation modern courts may and habitually do "think over again the thought which the legislator was trying to express," but that the Roman jurist went further and "thought out the thought which the legislator was trying to think." Of this freer mode of interpretation Windscheid might have found modern examples. The president of the highest French court, M. Ballot-Beaupré, explained, a few years ago, that the provisions of the Napoleonic legislation had been adapted to modern conditions by a judicial inter-

pretation in "*le sens évolutif*." "We do not inquire," he said, "what the legislator willed a century ago, but what he would have willed if he had known what our present conditions would be." In English-speaking countries this freer mode of interpretation has always been applied to the unwritten or common law, and it is usually applied to the written law with a degree of boldness which is very closely proportioned to the difficulty of securing formal amendment. Thus the rigidity of our federal constitution has constrained the Supreme Court of the United States to push the interpreting power to its furthest limits. This tribunal not only thinks out the thoughts which the Fathers were trying to think one hundred and twenty years ago, but it undertakes to determine what they would have thought if they could have foreseen the changed conditions and the novel problems of the present day. It has construed and reconstrued the constitution in "the evolutive sense," until in some respects that instrument has been reconstructed.

Every science classifies the phenomena with which it deals. In the law classification is especially necessary because, without classification of persons, of acts and of relations, it would obviously be impossible to lay down any general rules. In the early stages of legal development classification is crude: persons are either fully capable and responsible or completely incapable and irresponsible; acts by which property may be transferred or debt created are limited in number, and such acts are valid or invalid according as certain forms are or are not rigidly observed. In early law certainty is far more important than equity. In the later stages of legal development classification becomes increasingly refined, and, correspondingly, the law becomes more and more equitable; for equity, in last analysis, means discrimination. To this process, however,

there are necessary limits. In its most advanced development the law necessarily deals with typical persons, typical acts and typical relations; for if it should attempt to deal specially with variations from the normal type it would lose all certainty. In becoming absolute equity it would cease to be law. Modern society, however, provides special organs of discrimination, in such institutions, for example, as the pardoning power and the jury. The great social advantage of the jury is that it can bend the law in hard cases without creating authoritative precedents.

Every science, again, analyzes the phenomena with which it has to deal. In the law every act is resolved into its inward and its outward elements: crime becomes a combination of wrongful intent and illegal conduct; contract becomes a meeting of two corresponding wills in corresponding declarations. Every legal relation is resolved into its constituent powers or rights; and in spite of the very great variety of legal relations, the variety of legal rights is seen to be limited.

The conception of the legal right is to-day so familiar, and it seems so simple, that we can hardly realize with what difficulty it was attained. But as early law was wholly remedial and the substantive legal order which the remedies supported was only slowly recognized, so the legal right long lay concealed behind the correlative and essentially ethical notion of the duty. Brunner tells us that in the Germanic languages the word *Recht*, whether used in the sense of right or of law, is clearly younger than the other words for law; and Hozumi assures us that the Japanese language had no expression for the legal right until 1868, when a word was coined by a Japanese writer who had studied European law at Leyden. And only in our own time has it been clearly perceived that the legal right, previously regarded as the atom of all legal relations, is itself a combination of a definite interest and a limited power.

and that these two elements are separable. This was one of Jhering's great contributions to jurisprudence. Coupling this analysis with Burgess's sharp distinction between state and government, we see that it is in no sense inexact, as has been frequently asserted, to speak of public legal rights. Of course limited powers can not be attributed to the state, because the state is legally omnipotent; but limited powers may properly be attributed to any organ of government, and our public rights are in fact a combination of definite public interests with limited governmental powers. The possible developments of this line of thought in private and in public law are as yet imperfectly realized.

The final task of legal science is the orderly and convenient arrangement of all the institutions and rules of the law, public and private, substantive and remedial, in a logical system. The difficulties of this problem are very great, because of the innumerable points at which each part of the law touches every other part. Interrelations so complicated that the mind must work in a fourth dimension to apprehend them cannot be satisfactorily exhibited along the single line of a topical arrangement.

I have already indicated that the formulation of legal rules and principles has been, in the main, the work of practical jurists, men actively engaged in the administration of justice. The same statement may be made as regards legal classification and analysis, both in Roman and in English law. Not only has most of this work been done in the judicial laboratory, in connection with the discussion and decision of concrete cases, but the results obtained are largely embodied in judicial opinions. Moreover, the literature in which these results are presented has for the most part been produced by practical jurists. Nearly all the juristic writers of the Roman Empire were imperial judges (a few only were law professors), and their writings were substantially digests of the practice of the imperial su-

preme court. In English-speaking countries the legal literature has been less important; in these countries legal classification and analysis, like the rules of the law, are for the most part to be sought in the law reports; but in these countries, as at Rome, the most valuable contributions in these fields of legal science have been made by practical lawyers, by judges or by members of the bar. In this respect, again, the continental European development, during the middle ages and in modern times, has been different. In consequence of the arrested development of national law, recourse was had to the compilations of Justinian; because of the antiquity of these compilations their study centered in the universities; and from the eleventh century down to the present time nearly all the legal literature was written by professors. These writers were, indeed, by no means out of touch with the administration of justice. Not only were some of them judges, but until comparatively recent times university law faculties were frequently called upon to decide difficult cases. The relation between legal literature and applied law was, however, fundamentally different from that which existed in the most productive period of Roman jurisprudence and exists in English-speaking countries. It was a relation not of dependence but of control. The constructive work of the academic writers was based chiefly on that part of the Roman legal literature which is preserved in the *Digest* of Justinian. In this literature they had at their disposal a rich and admirably reasoned body of case-law. The decentralized administration of justice in the secular courts was producing no case-law comparable with the Roman in range or in quality. For all these reasons, legal literature obtained, and it still in a measure retains, a direct influence upon the decisions of the continental European courts which it did not exercise in the ancient Roman world until the period of legal decadence in the fourth and following

centuries, and which it has seldom exercised in the countries of the English law.

On the other hand, attempts to present the law or large parts of the law in systematic treatises have always been made under academic influences. Gaius, who wrote his *Institutes* of Roman law in the second century, and whose arrangement was generally followed, even in English-speaking countries, until the nineteenth century, seems to have been a law professor. The most important systematic works produced in France prior to the nineteenth century were those of Donellus and Pothier, both professors, although Pothier was also a judge. The modern German arrangement (*Pandektensystem*), which is replacing that of Gaius, was developed in university lectures; and a series of academic writers, from Savigny and Puchta to Windscheid and Dernburg, have given the Germans the most admirable body of systematic legal literature that has ever been produced. In England, the attempt to present the whole law systematically was made but once before the time of Blackstone, namely, by Bracton. Bracton was a judge, but he borrowed the whole framework of his treatise from Azo, an Italian law professor. Blackstone was a university professor, and his commentaries were prepared as lectures. In this country the systematic treatises of Story and of Kent grew out of academic instruction.

Philosophical theories of law demand our attention only in so far as they have strongly influenced or are strongly influencing the movement of law or of politics.

The life of man, the Stoics said, is but a part of the universal order. For the individual and for the state there are eternal and immutable natural laws with which human conduct and human laws should be in harmony. As regards human law, it will be noticed that this theory bears a singular resemblance to the orthodox judicial doctrine,

according to which every rule of law laid down in a judicial decision existed before it was discovered and enunciated. The natural-law theory gives to this eternal law, if not an objective basis or a demonstrable source, at least a name. The jurist-judges of the Roman Empire accepted the Stoic theory and used the name; and when a new rule was needed for the decision of a novel case, they drew from natural law the rule that seemed to them desirable. The mediæval church accepted the natural-law theory, adding the explanation that the natural order was simply a part of the divine order, so that when divine revelation was lacking the divine will was discernible as natural law. In the Roman Church as in the Roman Empire the discovery and the interpretation of the natural law were wholly in the hands of authorized experts.

Sporadically discernible in the ancient world is a theory that natural law is something more than a reservoir from which supplementary rules may be drawn when needed, that it is a superior law, and that human law that is not in harmony with natural law is of no authority. No Roman lawyer entertained this essentially anarchic theory. It received no countenance from the mediæval church as regarded ecclesiastical law; but it was accepted by the church as regarded secular law. Such law was void not only when it was contrary to the revealed will of God as interpreted by the church, but also when it was contrary to natural law as interpreted by the same authority. When in the sixteenth and following centuries it came to be generally held that neither church nor state had exclusive authority to interpret the divine will or the natural law, the theory that natural law was superior to positive law developed all its latent dynamic qualities. Natural-law theories were employed to legitimize revolution. "Is and ought to be" was the revolutionary formula for the assertion of every previously unrecognized right.

The reaction in favor of constituted authority produced both the positivist and the historical theories of law, or at least led to their more precise formulation. The positivist theory, as formulated by Hobbes, was a direct result of the English revolt against the crown. Hobbes did not deny the existence of natural law, but he asserted that it was not "law proper." The law of nature, he neatly remarked, "is become of all laws the most obscure, and has consequently the greatest need of able interpretation." Only the sovereign or the judges to whom he delegates authority are competent interpreters. This of course is the theory which was implicit in the Roman jurisprudence, but Hobbes was the first to make it explicit.

The historical theory was formulated in the reaction against the French revolution. The historical school found its antidote to the natural-law theory, not in the will of the sovereign, but in the authority of the past. According to this theory, presented in the field of public law by Burke, formulated as applicable to all law by Savigny, law is not made, it grows. The judge who declares it, the legislator who seems to make it, are simply interpreters of the national sense of right; and this in its turn is a product of the nation's entire historical existence.

To a certain extent the historical school also represents, at least in English-speaking countries, a reaction against the positivist school; less indeed against the theories set forth by Hobbes than against those formulated by the so-called "analytical" jurists. Confusing, as did Hobbes himself, the state with the government and finding sovereignty not in the crown, as did Hobbes, but in Parliament, the analytical jurists have always been inclined to regard legislation as the normal source of "law proper." Maine and other English adherents of the historical school have not only rehabilitated judge-made law, but they have restored custom to its ancient (and perhaps unduly exalted) dignity and importance.

Whether it is admissible to speak of a comparative school of jurisprudence, in the sense in which we speak of the natural-law school or of the historical school, may perhaps be disputed. It may be urged that comparative jurisprudence has produced no distinct theory of law. In the writings of Jhering, however, we find an interesting and, I think, typical reaction against the historical theory as formulated by Savigny. Without for an instant denying that law is a historical phenomenon, Jhering insists that it is not wholly nor even mainly a national product. Even national law is in the main a world product. The history of law, like the history of civilization, is a history of borrowings and of assimilations. Further, Jhering vehemently denies that law grows and asserts that it is and always has been made. It is a product of conscious and increasingly determinate human will. In this last assertion Jhering approaches the position of the positivists, but he lays less stress than they on the authority by which the rule is established, emphasizing as essential to the concept of law the possibility of enforcement. Noting the assertion of a contemporary writer that a certain custom was really law, only it was not enforced, Jhering replies: "We might as well say: This is fire, only it does not burn."

Each of these theories represents a partial truth. Many of the contradictions disappear when we realize that the natural-law theorists and the historical jurists are primarily interested in the substance of legal rules, the analytical jurists and the other positivists in the legal quality of the rules.

The historical study of law did not originate in the historical school of jurisprudence, nor were the laws of different peoples first compared when the comparative school formulated its theories. The extent to which law has always rested on precedents has always made it necessary for the lawyer to look back; and he has always been ready,

if he could not find a satisfactory precedent in the near past, to look back as far as any existing record or tradition has made retrospect possible. The use of the historical method in legal literature is also very old; and even that type of history which was recently described, in the non-technical lecture on history, as "morphogenetic" is distinctly visible in the *Institutes* of Gaius, written for the use of first-year law-students more than seventeen hundred years ago. Resuscitated by Cujacius in the sixteenth century, imbued with a due sense of its own importance by Savigny in the nineteenth century, morphogenetic history has been as assiduously cultivated by lawyers as by any other body of scientific men. The comparative method is, if anything, older than the historical. The story that, in the fifth century before Christ, when the Romans were thinking of putting their own laws into written form, they sent to Greece for a transcript of the laws of Solon, may not be true; but the fact that the story was believed in Rome in the early Empire is significant. In fact the Roman lawyers were actively engaged, in the last two centuries of the Republic, in studying and comparing the laws and customs of all the Mediterranean peoples, in order to establish a uniform commercial law—a problem which they solved with such success that the commerce of the world has ever since been governed, in the main, by the rules which they then formulated. Historical and comparative study of the law is prosecuted to-day on a more extensive scale and by more scientific methods than in any previous period, but these studies are new things only in the spirit in which they are being carried on and in the way in which they are now combined.

Legal history is being studied not only for the elucidation of existing law but for its own sake. It has become a part of general history, and one of the most essential parts. In political history its importance has long been recognized;

in social history its significance is still imperfectly appreciated. For many obscure periods of history, the legal material is the fullest that we possess and by far the most trustworthy. The interpretation of the legal material requires special training, but the results to be gained are well worth the labor. In course of time the synthetic historian will become aware that the legal material is that which he can least afford to neglect; that without the law of property and of contract, of family and of inheritance, of crimes and of torts, social history is as invertebrate and flabby as is political history without constitutional law.

Comparative legal study also is carried on to-day, not only for the practical suggestions which the legislator may derive from the accumulated and digested experience of other nations, but for its own sake. It has become a branch of the new science of society, and one of the sturdiest and most fruitful branches.

New also—an invention of our time—is the combination of the historical with the comparative method; and the results in every field of social science have been surprisingly rich. The comparative study of early institutions has been actively prosecuted during the last two generations, philologists and jurists, anthropologists and ethnologists, working side by side; and it is not too much to say that our conceptions of the beginnings of civilization have been revolutionized. Comparative work in the later stages of legal development promises a rich harvest.

These lines of study have carried the jurist far away from the practical tasks of interpreting and developing the law of his own time and his own people; and yet we are beginning to see that some of the results attained are of practical value. A vantage ground is being gained from which the existing law of each nation may be objectively examined and criticized. It is becoming more and more possible to see how much of any existing legal system is

dead or moribund, how much is vital. It is also becoming possible to see in what respects the law of each nation is in advance of other systems, and in what respects it is suffering from retarded development.

These studies, moreover, are preparing us to meet the great problem of the future—that of establishing world order and assuring the conditions of world progress. Even in the most progressive nations there are many unsolved social problems; but the world problem is forcing itself more and more insistently upon our attention; it will not be evaded or postponed.

The problems of world order and world progress can not be solved by international morals alone. In the international community, the law of the diminishing pressure of widening opinion is conspicuously verified; the influence of world opinion upon the rulers and peoples of the single states is very much weaker than the influence of national opinion; and the triumph of world morals over national morals can be secured only through international law. Rudimentary as this law is, it has already secured important gains. It has suppressed the slave-trade; it has forced the opening of all doors to world commerce; it has established the freedom of the open and the narrow seas; it has secured to all men the free use of the great navigable rivers of the world. Civilization is being carried into the backward portions of the world through the agency of the single national states, but international law is beginning to define the powers and duties of the states which undertake this mission.

In spite of the highly refined character of many of its rules, international law has as yet hardly reached the stage of development which European tribal law had reached in a prehistoric period; but the development is in rapid progress. In international arbitration the world has taken the

first steps towards international adjudication, but arbitrators have as yet no greater authority than is given them by the voluntary submission of the parties. World legislation is still in the contractual stage of development; it comes into existence only by unanimous agreement; an international congress is a Polish diet with the *liberum veto*. International conventions between great groups of states are, however, becoming increasingly numerous and important, and these conventions are reaching more and more into the field of commercial relations; besides the public law of nations a conventional private law of the world is in process of construction. The social force which is necessary to transform international law from a body of usages and agreements, supported only by moral sentiment, into "law proper" exists in the concert of the powers. This force has been exercised, thus far, only against backward or feeble states; but every case in which it is exercised establishes a precedent. All the essential agencies of legal development exist; they are becoming increasingly active; and it can hardly be doubted that the development will be more rapid in the next three generations than in the last three centuries.

At a similar stage in the development of tribal law the task of interpreting and guiding the social will was everywhere in the hands of priests; it was at a later period that the task was transferred to secular lawfinders. The world of to-day has many religions; it will listen to the secular jurist alone. It has been listening to him, largely accepting his rulings and his instructions, since the time of Grotius, the first of the world-lawspeakers. In the court of the Hague it is now replacing the naturally selected unofficial expert by the artificially selected official expert, the learned judge. In this new laboratory of world-law the bench will require the constant assistance of a learned international bar, and bench and bar will need all the help they can se-

cure from international legal literature. For centuries to come, perhaps during the whole future existence of the human race, there will be ample fields for juristic activity within the single nations; but the great task of the jurisprudence of the future will be to interpret the social will of federated humanity and to express in increasingly accurate and logical form the universal sentiment of justice.

SOCIOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
FEBRUARY 26, 1908**



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New York

THE COLUMBIA UNIVERSITY PRESS

1909

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Set up, and published March, 1908.

SOCIOLOGY

It was nearly two and a half thousand years ago that Clinias the Cretan, Megillus of Lacedaemon, and their Athenian friend, who, we surmise, wrote "The Republic" and "The Laws," sauntered along the way that led from Knossos to the cavern temple of Zeus. Loitering from time to time in the groves of cypress trees, they discoursed upon the question whether from the gods, or from the merely finite minds of mortal though gifted men, have proceeded chiefly those customs, rules, or laws which are the foundations of moral order in the state. As their dialogue flowed on, it revealed a sophisticated knowledge of affairs and a nicely graduated caution in generalization which proclaimed each one of the three to be that rarest and most excellent of beings, the philosopher who is also a man of the world. The vulgar view that laws are a gift from the gods they well understood; and that in a sense it could be accepted as true they acknowledged. The not less vulgar view that the mortal lawgiver has on the whole improved upon the lawmaking of the gods, they likewise understood; and that this view also in a sense is true, they acknowledged no less freely. But as they themselves viewed the complicated relations of man to his fellowman, his passions and his reasoned purposes, his manifold deeds of evil and of good, and called to mind the varied plans of

social organization which they had observed in the city states of their own Grecian world, they for themselves interpreted the divine lawgiving not as a proclamation from the throne of Zeus, but rather as a certain objective conditioning of individual and collective life by a thousand fortuitous forces to which man must accommodate his conduct. And the lawmaking of man they viewed as essentially the art of perfecting this accommodation of human conduct to objective facts and relations.

Their phrasing of this naturalistic philosophy was simple and straightforward, and admitted of no misunderstanding: "I was about to say," remarked the Athenian, "that no man is ever a legislator; but that fortune and all kinds of accidents happening in all kinds of ways, are our legislators. For either a war by violence has overturned politics and changed laws, or the want of means arising from severe poverty. Many innovations, too, diseases compel men to make, through pestilences falling upon them, and unfavorable seasons through many years. He, then, who foresees all this, will be eager to exclaim, as I just now did, that no mortal man was ever a legislator, but that nearly all human affairs are accidents. . . . On the other hand, it is equally possible for the person to speak correctly on these points who says . . . that although a god, and, together with a god, fortune and opportunity, govern all human affairs; nevertheless it is necessary to admit that art, a somewhat milder power, follows them."¹

Thus, in the land of the Gortynian law, where civilization millenniums old had begun perhaps as early as in Egypt or on the Babylonian plain, was stated the profoundest problem of social philosophy—may I not say of all philosophy—the problem of the interplay of human purpose with that external fate which we moderns call the reign of natural law, the question how far the collective life

¹ Plato, "The Laws," IV, 4.

of man is inexorably determined by the one, how far from time to time it may be shaped anew by his own clear-seeing reason and indomitable will.

Before we take up the question how far the solution of this problem which satisfied those men of Crete, of Athens, and of Lacedaemon, can suffice for us, whose intellectual standards have been both shattered and recreated by the new-born science of our later world, let us linger yet a moment more on certain further words in which they set their meaning forth. So strongly did they hold that man by constructive reason may create institutions potent to perfect his life, that they themselves were then devising a body of laws for an ideal commonwealth. And yet they held steadily before their minds the truth that their dreamed-of republic, if it were in fact to exist, must be composed of certain naturally coherent elements, and must conform to unalterable objective requirements. Once more I quote, and again it is the Athenian who speaks:

“For when a colony is of one race, and has the same language and the same laws, it possesses a kind of friendship as being a partaker in the same holy rites, and everything else of a similar kind, nor does it easily endure other laws, and a polity foreign to what it had at home. . . . But, on the other hand, a colony, composed of all kinds of people flowing together to the same point, will perhaps be more willingly obedient to certain new laws; but to conspire together, and, like a pair of horses, to froth together, as the saying is, individually to the same point, is the work of a long time and very difficult.”¹

In no later writing that I know do we find in so few words so many cardinal generalizations as these lines contain upon the nature and behavior of human society. They tell us, first, that of two familiar groupings of human beings, namely, groupings of kindred, and groupings

¹ Plato, “The Laws,” IV, 4.

of "all kinds of people flowing together to the same point," the second or miscellaneous grouping is no less spontaneous, no less natural, than the first. Secondly, they tell us that in the ethnically homogeneous group there is a psychological as well as a physical unity, a sympathy and understanding not to be looked for in the heterogeneous group. Nevertheless, as thirdly, they aver, not only in the homogeneous but also in the heterogeneous group, notwithstanding its defective mental unity, there is a collective behavior, which, however,—and this is generalization fourth—is more slowly and with greater difficulty in the miscellaneous group raised to the practical working level of collective action for the attainment of a common end. Fifthly, and finally, they declare that innovation—any voluntary breaking away from an old order of things to experiment with a new—is more likely to occur in the heterogeneous than in the homogeneous group.

Two thousand years of so-called progress have enriched and broadened knowledge. They also have multiplied the absolute number, possibly the relative number, of well-informed persons. They have multiplied, further, the relative as well as the absolute number of scientifically trained minds. That they have evolved individual intellects of greater power or of higher quality than were the best minds of Greece cannot be demonstrated. That they have multiplied the absolute number of men of genius is probable. That they have multiplied the relative number of gifted intellects is possible, but not certain. The civilization of Greece, in fine, was like some marvelous mutation in the realm of organic life, the advent of a new and glorious creation. Modern civilization is but the multiplication of its offspring. There has not yet appeared a nobler type.

Our one undeniable superiority, then, is a fact *not* of inherent quality, but of acquisition merely. It is our fuller

and more accurate knowledge and, underlying our knowledge, our more complex, our more rigorous methods of investigation. It is, in a word, our science.

In the light of our fuller knowledge it may be of interest now to re-examine the Grecian conceptions of collective life, of the nature, the origins and the uses of society, as the men of natural science, on their part, have re-examined, corrected and re-stated the Greek conceptions of the material world and of individual living things. Applying our stricter canons of scientific method, let us raise anew the questions of which Plato and his friends discoursed.

The continuity of all phenomena, within the limits at least of finite space and of finite time, is the master conception of our modern thought. There is no drifting molecule of dust that does not beat with impulse from solar systems very far away. There is no living thing that is not related in bonds of kinship to every other living thing. There is no conscious thought that has not a history which, if told, would be the story of all existence from eternity. There can be no theory, then, of any thing, or group of things, of any change, or series of changes, which is not a coördinate part of universal theory. Each science must not only be compatible with every other science, but, inseparable from every other, it must with them complete the unity of knowledge. Moreover, in every science the verdict of reason must accord with the verdict of sense perception. This accord, indeed, is the very substance of science, the innermost essence of verification. Science cannot identify or measure truth by standards of utility. It can only declare that this observation, or that generalization, accords with, or stands in conflict with, other observations, other generalizations. It may make for pleasure. We believe that in the end it will. For the moment it may con-

tribute only pain. With either result the scientific man as such has no concern.

Accepting this conception of scientific knowledge as the basic standard from which to judge the pretensions of any explanation or theory of collective life, we expect to find, and we do in fact find, that many sciences have something to contribute to the systematic analysis and interpretation of human society.

The natural groupings of human beings which are the bases of their community life are in no important sense unique. From botany and from zoology we learn that these groupings are common to all living things. The patches of lichen, the beds of moss, the forests of pine or of oak, the swarms of bees, the hills of ants, the shoals of fishes, the flocks of birds, the bands of squirrels, the colonies of beavers, the villages of prairie dogs, the herds of wild sheep, of antelope, of wild horses and wild cattle, the bands of monkeys, the tribes and nations of men, form an unbroken series of aggregations. In like manner, collective behavior is a phenomenon not peculiar to the human species. Comparative psychology assures us that from such simple beginnings as the simultaneous reaction of protozoöns to mechanical pressure, to heat, to light, to electricity, or to chemical action, up through the instinctive mutual aid of the ants, the sympathetically concerted action of pelicans in fishing or of wolves in hunting, to the deliberate coöperation of Australian savages in corroboree, or of Tammany braves in a political campaign, there is no point at which we can draw a line and with certainty say: Here mere physical response of sensitive matter to a stimulus passes into coöperative instinct or here coöperative instinct, in its turn, passes over into a reasoned coöperation.

The race of man, however, is more highly differentiated than any other species of living things, and the wide range

of human variation, both physical and mental, which anthropology describes, has determined a marvelous diversity of kind and of degree in the social groupings of human beings. Between the feeble hordes—the shifting camp-fire groupings—of primitive savagery, and those great aggregations of men in the Mediterranean basin who, with infinite toil, laid the pre-historic foundations of civilization, archaeology reveals endless gradations, while the peoples who upon these foundations have builded with political art the empires whose story the historian repeats, have played the drama of collective life with endless variations.

And throughout these gradations, this range of variation, there is order—the genetic order of evolutionary change, the balanced order of correlation. The presumption which biology establishes that the reign of natural law extends to every realm of the world of life is confirmed by the sciences of social phenomena. The economist, the student of comparative jurisprudence, the investigator of comparative politics, one and all assure us that the collective conduct of men is not fortuitous. The values of the market-place rise and fall, the activities of commerce ebb and flow as the tides of the sea. Law proceeds from law with the regularity of a birthrate. Parties and policies arise, flourish, and are lost in new issues with the sweep of a geometric curve.

There is, then, we must conclude, no branch of modern science which does not contribute something to the theory of man's social relations, and there is no aspect of these relations which may not be illuminated by any scientific discovery. Obviously, it is not only the structures and the functions of living things regarded as individuals that have awakened scientific curiosity, but, as well, the groupings of individuals and their collective behavior have fixed the attention of observers in many domains of inquiry. Under systematic scrutiny they have been revealed as

legitimate scientific data, admitting of examination by scientific methods.

Quite as certainly, however, the possibilities of the scientific study of society have not been exhausted by any of the sciences thus far named. Beyond the questions that have been raised by biologist and historian, by economist and student of politics, there are fundamental ones that thrust themselves upon attention.

important { What, for example, is the process of group formation? What are its conditions? What, if any, are its limits? What types or kinds of groups or of groupings arise? Similar questions we are compelled to ask about collective behavior. How does it begin? What are its causes? What types or kinds of collective behavior are there? How does it develop into concerted action for the achievement of a purpose? How far, under given conditions, does it take the place of individual action? To what extent does it become or does it create a constraining pressure upon the individual, in some degree controlling him and setting bounds to his liberty?

Again, when combined or collective action is long continued does it establish certain enduring relations among the individual actors participating in it, and are these relations that complex something which we call social organization? If so, what types or kinds of social organization may we discriminate? What are the stages of their genesis? What are their respective limitations? Do they tend to become fixed or rigid, or may they remain plastic, with a mobile and shifting membership?

Such questions provoke others. What consequences or reactions proceed from natural groupings and from collective behavior? It is commonly assumed that they create artificial conditions of security and opportunity. What, then, is their effect upon the process of evolutionary selection? What on the survival of any given race or stock?

What upon the amplitude and the richness of individual life? What upon the character of the individual and of the race? In a word, does the character of the mass determine the character of the individual, or is individual character fixed and determinative of the mass? Or yet, perhaps, within ascertainable limits, does each determine the other?

Finally, there is a profound question of interpretation, the ultimate question of causation. From the political sciences we have derived conceptions of teleological causation. We have been led to think of man as a creator, fashioning his social relations as he would have them for the achievement of ends which he has visualized. From biology we have derived the conception of an ecological explanation. Life proceeds through an adaptation of organism to environment. Environment moulds the organism, provokes and directs its activities, and determines its fate. Is social evolution, in like manner, an ecological adaptation? Granting that it is, is it also an idealistic striving? How far, then, may our interpretation of social relations legitimately be idealistic, how far must it be ecological?

Under careful examination these radical inquiries about social phenomena are seen to be closely clustered and correlated. Arising within a well-defined field of research, they are the problems of a logically organized science. Presupposing general psychology, presupposing also anthropology conceived as a special and concrete psychology of the racial varieties of mankind, sociology—the general science of society—is the true scientific foundation of such special sciences as political economy, jurisprudence and politics. As such, it has little in common with that portentous Science of All Social Things, good and bad, but especially bad, which has been invented for the sociologist by untethered intellects that live by describing things which

the non-journalistic eye hath not seen and defining things which have not entered into the merely academic mind to conceive. The sociology with which we are here concerned may be defined in the simple terms already used and repeated—as the science of the natural groupings and the collective behavior of living things, including human beings.

Social philosophy grappled in its youth with its most difficult questions, those, namely, of personal causation and of the action of society upon the individual character. This was not because systematic inquiry into the nature of society was a legacy from anthropomorphic ages. On the contrary, it was because it arose in that Grecian world where, for the first time, man had become in the true sense of the word a citizen, and had experimentally demonstrated that, through a free and plastic social organization, he could in a measure control his own economic and moral destiny. In Egypt and in Babylonia political integration, hastened and hardened by empire-making militarism, had brought all the eastern lands under a remorseless despotism. Peoples once free and happy had been so crushed by exploitation that hope itself had almost died within them. Despairing of redress at the hands of any earthly power, and distrustful of themselves, they could only create and embrace, according to their temperaments, the religions of resignation, or those of apocalyptic vision. In the Aegean Grecian world geography and race had conspired to prevent a too rapid centralization of power. The city states were still free and proud. Man still believed in himself and respected his fellow man. Rejoicing in political as in artistic creation, loyal to the state which his own thought had fashioned, he believed that he could make it perfect, and thereby perfect himself. Therefore it is that the first comprehensive work on the nature and possibili-

ties of human society which has come down to us from the past was the utopian "Republic" of Plato.

The imperishable contribution which this work makes to our reasoned knowledge of human society is found not in its communistic plan of life, but rather in its analysis and its correlation of moral and social forces; above all, in its actual solution of the problem of social reaction upon individual character. Assuming that man as a personal cause can in fact mould the commonwealth to his will, assuming also that the final end of endeavor is the attainment of a good life—which should consist substantially of those kinds and degrees of pleasurable activity that reason can approve of—the "Republic" demonstrates that the "good life," so conceived, after all depends upon a certain objective condition which reason and the human will may create, and which is called "justice." Moreover, reason and will cannot create justice directly. They can establish it only through the fine adjustments of a social order. Thus, in the thought of Plato, the "good life" is a function of "justice," and to maintain justice is the function of social organization.

It was but too obvious, however, to the men of Athens in its Periclean Age, as it is to us to-day, that not all society establishes justice, and that not all so-called justice yields the fruitage of good life. It was inevitable to ask whether the failure is wholly attributable to man's fault or weakness, or is caused in part by those vicissitudes of fortune which, as Plato himself admitted, finally govern all human affairs. It is to this problem that Aristotle turns in "The Politics," in some respects the most masterful treatise upon human relations that has yet proceeded from either the ancient or the modern mind. Based upon an inductive study of one hundred and fifty-eight Grecian constitutions, it analyzes the nature and functions of the state, it classifies and critically compares the forms of government,

it exposes both the inherent and the adventitious limitations of each, and reveals the causes of political change, including revolution, that lie deep in human nature, in historical experience, in geography, climate and soil, and in other circumstances of external fact. Thus, while fully recognizing the creative part of conscious purpose, Aristotle carries explanation back to impersonal causation. He lays the foundation for an ecological interpretation. Inductive also in his method, where Plato is speculative only, his work is more strictly a scientific study of society.

While Plato was interested chiefly in problems of the social welfare, and Aristotle chiefly in the antecedent problems of social organization, they did not quite neglect a multitude of facts that are dynamically antecedent to association, as organization is functionally antecedent to welfare. Aristotle, especially, was curious about the nature of those bonds of feeling and purpose which hold men together in agreeable or useful organization, and in his chapters on Friendship, in the "Nicomachean Ethics," he recognizes the importance of that sense of similarity, which, long before his day, had been expressed in the proverb that "birds of a feather flock together," and by Empedocles in the saying that "like desires like." Perceiving that this social sense is instinctive, he built the argument of "The Politics" upon the postulate that man is a political animal.

This simple theory of the social mind was both broadened and deepened by the disciples of Zeno. Alexander's conquests brought into one political system Thracian and Athenian, Asiatic and Egyptian. In the cosmopolitan atmosphere of the Macedonian Empire the brotherhood of man became for the first time a practically important fact, and stoic philosophy, reflecting upon the moral consciousness common to barbarian and Greek, explained it as the conformity of human reason to a universal reason immanent in nature. This interpretation goes to the bottom of

things, for it is equivalent to the proposition that resemblances and sympathies have their origins in like adaptations of otherwise differing men to the same objective fact or universal law.

With cosmopolitanism, however, came individualism, and with it the final word of Greek philosophy upon the social relations. Epicureanism, with its emphasis upon individual initiative and individual happiness, contended that the society is best which imposes minimum restraints upon the individual will. From this doctrine as a premise, the conclusion was inevitably reached that social and legal relations rest wholly upon individual self-interest, and the desire of each to secure himself against injury. The true origin of society was therefore to be sought in contract or consent. Thus the teaching of Plato and of Aristotle was turned about. The assumption that society creates and moulds the individual became the dogma that individuals, for individualistic ends, create society. }

In the further development of social philosophy from these Greek beginnings, the historical evolution of society itself continued to be the chief formative cause. To the Roman mind, with its genius for political organization, the problems of organization in general made strong appeal. But the great achievement of Roman intellect was its analysis and correlation of the facts from which organization proceeds. The conflicts of mind provoked by conflicts of interest, the meeting or concert of minds, the emergence therefrom of contract, and the ultimate expression in law of the collective reason and final decision of the community—these phenomena were more completely understood and more accurately described by the Roman legal writers than by the Greek philosophers. While “The Republic” and “The Laws” of Plato tell us what laws ought to be, “The Republic” and “The Laws” of Cicero tell us what laws are and how they came to

be. The Romans, moreover, by their conquest, incorporation and assimilation of many diverse peoples, acquired a knowledge never before attained of the ethnic composition and other physical phenomena of a social population that are determinative of the social mind, and to this day there are no better descriptive studies of some aspects of ethnic character and influence than Caesar's "Gallic War" and the "Germania" of Tacitus.

The rise of the Christian Church and the extension of its authority from Rome to the remotest frontier of the secular empire offered to contemplation a new and magnificent social order. It presented new ideals of human well-being and a comprehensive organization. Claiming to be in truth that City of God which Augustine portrayed, it demanded recognition from kings no less than from people as a universal society within which the secular state must henceforth take a subordinate place. To vindicate not only the historical, but also the rational claim of the secular empire over the ecclesiastical power, was the purpose of Dante's "De Monarchia."

It was not chiefly by argument, however, that the conflicting claims of secular and ecclesiastical authority were adjusted. The secular state established its dominion by force, and thereby brought again into the foreground of consciousness the questions of social psychology. For political force is something more than the *vis viva* of a physical body. It is the conquering power of a political body, the cohesion and self-directing quality of which are not accounted for by instinct and sympathy only. It is a commanding because it is a commanded group. A chieftain speaks and followers obey. A prince rules and subjects render service. With amazing precision, Nicolo Machiavelli analyzed the psychology of this relation as it had never been analyzed before. The leader obtains obedience through his power to browbeat lesser men, to inspire

and to awe. He is feared and revered not so much for his physical strength alone, as for his nerve, his resourcefulness and craft; because he is the fearless man in the midst of men who fear. Collectively they could make an end of him, but that is the last thing they would wish to do. For, deeper and more overmastering than their fear of him is their fear of a hostile world environing them and forever threatening their existence, and they have discovered that their man of iron is able to make that outer world fear him as they also fear. Loyally and without question obeying him, they are safe. They conquer and make their way, they build the state and extend its domain. The alternative is servitude or extermination. Therefore, the supreme duty of the prince is to maintain his authority. The supreme duty of the state, whether principality or republic, is to maintain its dominion and its vital quality of growth. Greek civilization was overwhelmed because the Greek ideal was a static perfection. Rome, expanding, became mistress of the world. Consequently, to the conduct of the prince and to the policy of the state, profounder standards than those of ordinary morals apply. Self-preservation through adequate power and ceaseless growth, is the supreme law. The social order may not rightfully be permitted, for moral reasons, to disintegrate, as the Queen of Siam was left to drown because it would have been sacrilege to lay hands upon her sacred person. Machiavelli did not see in the struggle for existence all that Darwin was to discover in it, but he did grasp the tremendous truth that out of it springs social life, to be forever conditioned by it, and that no system of state-craft or of ethics which is constructed in lofty disregard of it can be other than childish.

After Machiavelli, it was easy for the political theorists, Bodin and Althusius, to construct their concepts of sovereignty and the state. Society, as Bodin taught, arises

from instinct and is developed by experiences of the pleasure and utility of association. Within the bosom of society the state is created by force, and sovereignty is supreme political power "over citizens and subjects unrestricted by the laws." This conception was more simple than the facts, some of which Althusius more clearly perceived. Defining sovereignty as the supereminent power of doing what pertains to the spiritual and bodily welfare of the members of the state, Althusius argued that it inheres in the totality of the people and cannot be alienated or delegated. So conceived, sovereignty is the supreme form and expression of a social will, and as such it is the focal phenomenon of the social mind.

Demonstration, finally, that society and the state, a social will, rightful authority, and political power, have all one common and inevitable origin, was the achievement that Thomas Hobbes essayed. Writing in an age when royal absolutism was striving to maintain itself against popular revolt, Hobbes derived both society and sovereignty from a covenant whereby men in a state of nature escape from intolerable ills. Freely and gladly yielding their individual wills, men alienate their natural sovereignty, and the monarch or the parliament so obtaining authority rightfully rules absolutely, wielding force to any necessary extent. If any one has refused to join in the covenant, he has elected to remain in a state of nature which is a state of war. He therefore cannot complain if force is used against him. If, however, the titular sovereign fails to maintain his authority, society is resolved back into anarchy, and the social covenant must be re-made. Therefore the revolution that succeeds is right. There is probably not in all literature, outside of the exact sciences, so complete an example of remorseless logic as "De Corpore Politico" is.

Its one vulnerable point, namely the premise, was per-

ceived by Locke. Denying that the state of nature is one of war, or for any reason intolerable, since men of one blood and kindly disposed, spontaneously aid one another, Locke contends that the people never alienate their natural sovereignty. A natural society, they forever are the state, the source and real wielder of power, although artificially by covenant creating institutions for utilitarian ends and delegating a limited authority to governments.

Like history, social theory had now repeated itself. From new utopias and the doctrine that the scope and character of social organization determine the quality of individual life, it had returned to the conclusion of Epicurus that individuals in a purely rationalistic way create society for individualistic ends.

Throughout this long development and in all the various phases that it had assumed from Plato to Locke, social theory, while not neglecting observation or ignoring external cause, had been on the whole speculative, or, to use Professor Karl Pearson's word, "ideological," and its interpretations had been chiefly in terms of subjective causes, namely, motives and reasons. But from ideological beginnings, science, as Professor Pearson contends, becomes in the second stage of its evolution observational, and, finally, in a third stage, metrical or quantitative and in a strict sense of the word inductive.

In Montesquieu's "Spirit of the Laws" the speculative methods of the social philosophers are frankly abandoned. The work is descriptive and its conclusions stand or fall with the accuracy and sufficiency of concrete facts, from which the conclusions are derived by generalization. That this work, as judged by modern standards, is elementary and crude should not prevent our recognition of the service it rendered in turning attention to inductive method, in awakening interest in purely objective interpretations of

social phenomena, and in stimulating by suggestion and example those researches which have accumulated for the use of scholars to-day an enormous mass of ethnographic and other descriptive sociological material. Montesquieu converted social philosophy into descriptive social science.

Meanwhile, the beginnings of quantitative investigation had been made. Ancient states enumerated their populations for purposes of taxation and military service. The Roman census was taken at five-year intervals, and there were probably at least seventy such enumerations. The medieval church kept records of marriages, births and deaths, primarily for the purpose of deciding disputed cases of kinship-degree barring sacramental marriage. The Domesday survey of England, ordered by William of Normandy, is an admirable document of descriptive sociology. Manorial records in many instances are accurate and detailed descriptions of local communities.

Masses of figures, as such, however, are descriptive only. They may be profoundly significant, but they yield their meaning only to interpretative analyses that involve the use of somewhat refined mathematical methods. The first step in this direction was taken by the astronomer, Edmund Halley, in 1693. John Graunt had compiled interesting tables of mortality, but had not derived from them any important induction. Halley drew up a life table from observations in Dresden, from which he demonstrated what proportion of all persons born in any given year would die or survive in each succeeding year. This was the first true inductive generalization of law in the realm of social phenomena. To the influence of another great mathematician and astronomer, Laplace, the subsequent developments of quantitative method in sociological research must in large measure be attributed. Laplace's marvelous mind ranged over the whole field of human knowledge. He drew about him the original and inter-

esting men of his time. Among these was the younger mathematician, Jean Baptiste Fourier, whose monographic studies of the city of Paris revealed the possibilities of scientific inference from statistics of aggregation, of births and deaths, and of distributions of population by age and sex. The Belgian statistician, Quetelet, whose "Physique sociale" and "Sur l'homme" were the first serious attempts to extend statistical methods to a study of the mental and moral phenomena of society, acknowledged his indebtedness to Fourier and through him to Laplace.

It is well to linger a moment upon the specific and important contribution that Quetelet made to a quantitative method in social science. It consisted in certain applications of the theory of probability. Things that happen by chance reveal in their grouping or arrangement a remarkable uniformity. When a cartload of bricks is dropped upon the ground, the individual bricks scatter in every direction, but more of them fall closely about a central point than elsewhere, and the aggregate is a roughly rounded pile. If hundreds of bushels of wheat comprising millions of individual grains fall from a shute to a floor below, the rounded pile presents an exceedingly accurate symmetry. This means that the greater the number of chance distributions of any given kind, the more precise is the regularity of their distribution. Mathematically it is represented by a curve, known as the probability curve, or the curve of error.

This term, "curve of error," has also an interesting significance. If a hundred different men should measure the extreme length or the extreme width of this hall in which we are gathered, their results, however carefully they did their work, would not precisely agree. The measuring rod or line might undergo slight changes, and men differ in manual dexterity and in accuracy of sight. Assuming that there is a true value or measure of the distance in question,

the actual measurements differ from it by certain "errors" or "deviations." Now if these errors have been made purely by chance, their distribution corresponds to the probability curve. If, however, they have been subject to some disturbing cause or bias, their curve is unlike the probability curve. Here, then, is a principle which can be and has long been used to determine the accuracy of scientific observation and measurement, both for theoretical purposes, as in astronomy, and for practical purposes, as in engineering.

But, obviously, the principle has a more profound meaning also. Any distribution of a great many numerical items which noticeably differs from the curve of probability reveals specific causation. It tells us at once that we have to look for a cause which is creating effects different from those that might happen by chance, and by its form it may give us some hint of what the cause is or where to look for it.

And even this meaning is not quite all. The curve of probability gives us the only precise meaning of the term "scientific knowledge." We have seen that human observations and measurements are never precisely accurate. Generalizations, in like manner, are never precisely true. The formulation of a law of nature can never be made absolutely exact. Scientific knowledge, therefore, is not that absolutely exact and certain knowledge which the popular mind assumes it to be. It is certainty or exactness within a range of error, and to diminish that range is the object of scientific endeavor. When, therefore, we are told that recent work in astronomy demonstrates that the Newtonian laws of motion and the law of gravitation, as Newton formulated it, have been corrected by a decimal or two, we are not told that these laws are invalid and that science, after making a wonderful splurge in the world, has arrived at bankruptcy, as M. Brunetière so dogmatically

proclaimed; we are told only what any modest scientific gentleman of fair mathematical attainments could very positively have *foretold*.

That the ideas and the methods of Laplace greatly influenced the thought of Auguste Comte, we have abundant evidence. Although he was a teacher of mathematics, Comte did not develop his own generalizations by mathematical methods. But he did grasp and exploit the notion that science differs from speculative philosophy in virtue of its limited range no less than by reason of its practice of verification. Science can tell us how things are distributed in orderly coexistence and in orderly sequence, and it can discover with what other distributions any given distribution is most closely correlated. The various sciences themselves, Comte contended, are related to one another in a sequence at once genetic and logical, and to the complete body of knowledge which they collectively present he gave the name "Philosophie positive." In his hierarchy, mathematics is the initial, the most abstract, and the most general science. The science of society is most concrete and special, and it is the final science to which all sciences that go before it are tributary. To distinguish the comprehensive social science from all fragmentary studies of society, dealing in their various ways with more or less definite divisions of social phenomena, and to mark it off as a body of pure knowledge from all programs of social reform, he called the social science "La sociologie." As Comte conceived it, sociology should exclude theological and metaphysical explanations, and keep itself distinct from ethical applications. Above all, it should keep itself free from the revolutionary spirit. In his youth Comte had been a disciple of Saint Simon, but he had wearied of revolutionary reform, and had come to believe that enduring social reconstruction must stand on firm and broad foundations of scientific knowledge.

Comte predicted sociology; he did not himself create it. The first strictly sociological treatise was the "Social Statics" of Herbert Spencer, published in 1850. Without either accepting or rejecting that comparison of Spencer to the great intellects of Greece, which his more ardent disciples have made, it may at once be acknowledged that the "Social Statics" challenges comparison to an extent that perhaps no other writing does, with both "The Republic" of Plato and "The Politics" of Aristotle. It propounds the same problems which they discuss, and it offers solutions which, though not identical with theirs, are closely parallel to them. The object of human effort for Spencer is happiness: and as he conceives of happiness, it does not greatly differ from the joy of rational activity which was the "good life" for Plato. Happiness depends upon external conditions, which are, namely, liberty and justice. Justice, however, for Mr. Spencer, is that limitation of liberty which equalizes it among men, whereas for Plato it was that specialization of work and opportunity which enables every man to do what he can do best, and to be what he can be perfectly. Both writers agree that to establish justice is the purpose, or function, of society.

So far there is nothing essentially new in the "Social Statics." But at the end of the book there is a discussion of the dynamics of society, the radical originality of which no well-informed critic has ventured to call in question. Society obviously is not at present in the perfect equilibrium of equalized liberty. Are social tensions and pressures, then, tending, Mr. Spencer asks, toward equilibrium? Have they been tending toward it from the beginning, and if so, to what causes may the progressive recombination of forces be attributed?

Mr. Spencer resolves these questions into the problem of human nature. No mere social mechanism will ever maintain the justice of equalized liberty in a community

of men whose supreme desire is to exploit the imperfections of the law. The equilibrium of conflicting interests must be established in the human heart, as in outward relations. The assumption of political science, as of theology, had been that human nature is unchanging until converted by supernatural agency. Political science, influenced and colored by theology, had pictured unchanging human nature as essentially evil, self-seeking and ruthless. The eighteenth century, reviving Epicurean individualism, reaffirmed also the doctrine that human nature is essentially good. The apparently intermediate position of Platonism and of Stoicism that man as a composite being is neither wholly good nor wholly bad, and that he is modifiable by adjustment to an objective law or condition, had reappeared in the teaching of Montesquieu and of Condorcet—which culminated in the historical philosophy of Buckle—that the human mind is directly or indirectly moulded by the topography, soil and climate of its physical environment. These writers, however, did not go so far as to assume that the inner moral nature of man, that essential character which theology represents as by nature sinful, is so moulded. They argued only that man's temperament, his emotions, his ideas, and his superstition or his rationalism, are affected by physical conditions. The proposition that human nature at the beginning of a long evolutionary process was wholly and monstrosly evil, and that, under the action of a specific natural cause which can be identified and formulated, it tends to become altogether good, is Spencerian, and is new.

Accepting the generalization, which Lamarck had made familiar in biology, that living things are ceaselessly transformed through a continuing adaptation of organism to environment, and assuming, therefore, that habitual activity determines human character, as habitual functioning reacts upon the bodily organ, Mr. Spencer perceived what

all interpreters of society before him had overlooked, the real significance of political integration. At the beginning of human progress, small social groups were so situated in relation to a common food supply that they were almost continually engaged in relentless warfare, but when, through successive conquests, small groups had been united in great states or national federations it became possible for a majority of men to give up military pursuits and devote themselves to arts of peace. Herein, as Mr. Spencer saw, lay not only the possibility, but also the certainty, that primitive human nature, a product of the adaptation of the primitive man to the conditions of his existence, must be as brutal, as cruel and as treacherous as theology had ever pictured the unregenerate human soul, but that developed man, under wholly different conditions must necessarily be transformed into the sympathetic, the kindly, the helpful being who can live on good terms with his neighbors, and in coöperation with all mankind.

In this thesis of the concluding pages of "Social Statics" we have the germ of Mr. Spencer's rounded doctrine of evolution. Explicitly, or by implication, it contains all the cardinal propositions of the "Synthetic Philosophy": that equilibration is the primary cosmic process; that integration and differentiation are necessary consequences; that life is a correspondence of internal to external changes; that mental evolution is the extension of adjustment in space and in time; that social evolution is progress from militarism to industrialism; that moral evolution is the conciliation of egoistic and altruistic impulses.

Mr. Spencer's sociological books are many and voluminous. We nowhere find in them a compact and logical summary of his sociological system. The following scheme of propositions was not made by him, but it received his endorsement:¹

¹ In a letter to the author, December 7, 1900.

Societies are organisms, or they are super-organic aggregates.

Between societies and environing bodies, as between other finite aggregates in nature, there is an equilibration of energy. There is equilibration between society and society, between one social group and another, between one social class and another.

Equilibration between society and society, between societies and their environment, takes the form of a struggle for existence among societies. Conflict becomes an habitual activity of society.

In this struggle for existence fear of the living and of the dead arises. Fear of the living, supplementing conflict, becomes the root of political control. Fear of the dead becomes the root of religious control.

Organized and directed by political and religious control, habitual conflict becomes militarism. Militarism moulds character and conduct and social organization into fitness for habitual warfare.

Militarism combines small social groups into larger ones, these into larger and yet larger ones. It achieves social integration. This process widens the area within which an increasingly large proportion of the population is habitually at peace and industrially employed.

Habitual peace and industry mould character, conduct and social organization into fitness for peaceful, friendly, sympathetic life.

In the peaceful type of society coercion diminishes, spontaneity and individual initiative increase. Social organization becomes plastic, and individuals moving freely from place to place change their social relations without destroying social cohesion, the elements of which are sympathy and knowledge in place of primitive force.

The change from militarism to industrialism depends upon the extent of the equilibration of energy between any

given society and its neighboring societies, between the societies of any given race and those of other races, between society in general and its physical environment. Peaceful industrialism cannot finally be established until the equilibrium of nations and of races is established.

In society, as in other finite aggregates, the extent of differentiation and the total complexity of all the evolutionary processes depend upon the rate at which integration proceeds. The slower the rate the more complete and satisfactory is the evolution.

Mr. Spencer organized sociology as a science, and he demonstrated principles which must always hold a central place in sociological theory, whatever its further development may be. But his analyses are by no means always exhaustive, and he raised many questions which he left unanswered.

The most fundamental question that his exposition left open, and over which dispute soon arose, is that of the true nature of the social aggregate. Is it, strictly speaking, an organism, or is it more accurately described by Spencer's alternative phrase—a super-organic aggregate? A group of able writers, among whom Schäffle and Lilienfeld in Germany, and René Worms in France, have been most active, has strongly insisted that the typical society, consisting of individuals both dwelling and working together, is as truly an organism as is the animal or the vegetal body composed of cells and differentiated into mutually dependent tissues and organs. Preëminently fruitful work, however, has been done by investigators, who, conceiving society as a super-organic product, regard it as essentially a psychological phenomenon. They assume that all social bonds, instead of being merely physical, like the cohesion of material cells, may be resolved into some common activity or some interactivity of individual minds.

When this assumption is made, the further question

arises: What definite mode of mental action is the most elementary form of the social relation? There are four possibilities, namely, reason, impression, imitation, and like-response to common stimulation.

The Platonic and the social contract theories assume that men perceive the utility of association and with conscious purpose endeavor to perfect it. The social bond, therefore, is reason. Machiavelli and the writers on sovereignty discovered the social rôle of that mental phenomenon which modern psychologists call impression, the power, namely, of the strong personality to awe or inspire the many, the power of the mass to overawe the individual. This phenomenon Durkheim and LeBon with great ability have maintained is the distinctly social or society-creating activity of the mind. In "Il Convito," Dante descriptively analyzes the familiar fact of imitation. The passage is of curious interest, because it pictures imitations as subject to refraction by media—the copy not being quite like the example—as spreading in a geometrical progression, and as setting up contradictions or duels among themselves. There is no evidence that Gabriel Tarde derived the theses of his brilliant "Les lois de l'imitation" from "Il Convito," but it would not matter if he did. Nor does it matter whether M. Tarde derived much or little from the acute discussion of imitation by Walter Bagehot in the "Physics and Politics." Tarde examined imitation and all that can be shown to proceed from it with thoroughness and penetration. He gave to the word a precise and characteristic meaning, that of the action at a distance of one mind upon another, whether consciously willed or not willed, passive or active. If it were possible to demonstrate that society is but a tissue of imitations defined as intermental actions, it would be difficult to add much of interest or value to Tarde's argument.

It is demonstrable, however, that neither imitation nor

impression is the most elementary social fact. It long ago became unnecessary to argue that reason is not. When an audience springs to its feet at the cry of fire, its initial action is not imitation. Example and imitation enter as complicating factors the instant that movement toward the doors begins. The power of impression—of a cool and fearless man to overawe and quell—may then, by some rare good fortune, intervene to prevent panic, until reason can direct an orderly dispersion. The initial action is merely like-response to a common stimulation. In terms of like or of unlike, of prompt or of slow, of persistent or of intermittent response, all the phenomena of natural grouping and of collective behavior can be stated and interpreted. Intermental action is interstimulation and response. Like-response, complicated by intermental action becomes concerted volition. Like-response creates solidarity; it integrates. Unlike-response disintegrates, or, becoming competitive activity, it differentiates and individualizes.

If some such explanation of the psycho-social process is tenable, it goes far to resolve the difficulties that are presented by an apparent dualism of social causation. While the material environment is the original cause of society and of social evolution it is so not merely as a compelling power, but rather as an infinitely differentiated group of stimuli. The products of response, including personal influence, conscious motives and ideas, and the historical tradition, reacting as secondary stimuli, are real and immediate, although in a strict sense secondary, causes of social change. Both groups of causes, the primary and the secondary, act upon brain and nerve cells in precisely the same way, not in crude compulsion, but by provocation.

By means of this conception of social causation, the present correlation and coördination of sociological problems is effected. The hypothesis of environmental pres-

sure, which long and acceptably has served political economy, and more recently has been made the postulate of an economic interpretation of history, is both valid and useful as far as it goes, but the sociologist contends, and the present-day economist concedes, that it must be supplemented by the hypothesis of environmental stimulation, which we owe to the newer ecological developments of biology and psychology. The environment not only starves, crushes and kills: it also sustains, energizes and incites, and the well-being of the organism depends upon the ratio of environmental stimulation to environmental pressure.

From areas of relatively high environmental pressure, and relatively low environmental stimulation, animals and men move, to such extent as they are able, to areas of relatively high stimulation and relative low pressure. The competitive struggle of migrating or colonizing aggregates to occupy the favorable regions constitutes for each aggregate or group a supplementary environmental pressure, while the contact of groups and their intermental activity constitute for each a supplementary environmental stimulation.

Under the action of these forces, populations assume varying degrees of density and of composition. According to their density and composition they react with more or less unity to a multiplying number of common stimuli, thereby becoming more or less homogeneous in feeling, thought and purpose. Through ever-increasing intermental activity, they become increasingly conscious of their differences and resemblances. This consciousness of kind, combining with and supplementing like-response to stimulation, and converting it into concerted action, gives to it at times a significant direction.

For concerted action greatly modifies the relation of organism to environment. Among human beings it very

nearly transforms it. It shields or removes individuals from destructive forms of environmental pressure. It multiplies their contacts with environmental stimuli, and, above all, it so extensively recombines natural elements and forces, and so effectively directs their discharge through new channels, that the environment itself, so far as its specific relation to man is concerned, is profoundly altered. Its adverse pressure upon him is diminished, its positive contribution to him and its stimulation of him are increased. Society, accordingly, achieves an end; it has a function. It is an agency for increasing the ratio of environmental stimulation to environmental pressure, thereby enlarging the volume and raising the quality of life.

Now, individual differences of opinion and of ability may raise coöperation to a maximum effectiveness, while certain differences of attitude or of conduct may diminish its effectiveness or even destroy it. Human societies, perceiving these complications, become sensitive to the practical bearing of ethnic unity and of moral solidarity. Differences of blood and of speech, of creed and of conduct arrest attention and awaken distrust. Unconsciously in part, but consciously also in some measure, a great deal of collective action is directed upon the task of stamping out certain individual differences among men. Such collective action is a true social pressure, a constraining power of the social mass upon the social units. Its understood purpose and its actual function is to increase the practical effectiveness of society as an instrumentality for the protection and improvement of life. Exterminating or restraining the anti-social, it selects for survival and encouragement the sympathetic, the intelligent, and the self-controlled, thereby converting the biological survival of the fit into a survival of the best. Nevertheless, being repressive and destructive, social pressure curtails variation; it limits dif-

ferentiation; it checks spontaneity; it sets bounds to individuality, and tends to create rigidity of social organization. It is of maximum utility, therefore, when it is just strong enough to control and to eliminate the elements that obstruct coöperation, without limiting the free activity of elements that already are adapted to social life. The social pressure that exceeds this degree is injurious and is justifiable only when it is the substitution of a less repression from within for a greater threatened repression from without. That society best fulfils its purpose which maintains a highly organized and effective coöperation with the least social pressure.

That social pressure tends to increase when environmental pressure increases, is a conclusion suggested by history and by current observation. Not only does the struggle of the nations to obtain room for their multiplying millions create coercive policies, as Mr. Spencer explained, but so also does the intense economic competition of lesser communities with one another create such social pressures as the prohibition movement, which has swept over large sections of the United States.

To the extent that society succeeds in shielding man from destructive environmental pressure, and multiplying the stimuli that act upon him positively, it converts a generic evolution into the specific thing—progress. Integration and differentiation, correlation and coördination, fill out the formula of evolution, but they are not necessarily a betterment of conscious existence. Evolution is also progress when each unit of the integrated mass or group becomes an end as well as a means. In the evolution of vegetal and of animal life there has been much ruthless sacrificing of the individual to the race. In human evolution the race has been maintained and differentiated at a diminishing cost to the individual. This has been accomplished by and through society. In the higher types of

civilization, individual freedom and well-being are continually increased without necessary injury to the race. Race maintenance and evolution with diminishing cost of individual life, with increasing freedom, power and happiness of the individual person,—is progress.

Thus far, sociology at its best has been chiefly a descriptive science, a logically organized body of observations. Of late, through an increasing use of statistical methods, it has rapidly been taking on the quantitative character, until now it promises to become in a rather high degree an exact science.

To make this possibility clear, it is necessary to call attention to the extraordinary significance which that very simple numerical term, the arithmetic average, has come to have in the theory of evolution.

If there is a struggle for existence in which certain organisms perish, while others survive, it is plain that the survivors tend, under given environmental conditions, to become alike, since all must possess those structural peculiarities and those habits which give advantage over competitors. The more specific the conditions and fierce the struggle, the more surely is an individual marked for destruction if he varies greatly from the successful type or norm. Now most peculiarities of organic structure and activity admit of measuring—like height, or of counting—like the number of veins in a leaf. The measures or other numbers relating to thousands of individuals may be brought together in columns or tables. Their averages may be obtained, and the difference between each number and the average of all numbers of the same class may be found. Then, if the numbers, as shown by their deviations, have a wide dispersion from the average, we know that the individuals to which they relate have not for a long time been subjected to a relatively intense struggle for existence. It has been possible for them to vary within wide

limits, and yet to survive. If, on the other hand, the numbers cluster closely about their average, we know that the individuals to which they refer have been subjected to a severe unifying pressure. They have ceased to vary because such as strayed from type lost their hold on life.

Ingenious applications of this principle in connection with the curve of error, and other statistical devices, which have been developed by Sir Francis Galton, Professor Karl Pearson, and many others, have proved to be of inestimable value in biology, in psychology, and in anthropology. There is reason to believe that in sociology the results will presently be yet more satisfying, since in all statistical operations the possibilities of error diminish as the number of numerical items of any given class, and happening to be available for analysis, increases. Sociology will preëminently enjoy this advantage.

The first attempt to make a statistical statement of the greatest possible number of sociological problems, and to indicate their statistical solutions, we owe to Professor Mayo-Smith. It was possible when he wrote to give precision to statistical studies of population at one end of the series of social phenomena, to studies of organization and welfare at the other end. The intermediate and crucial problems of mental type and variability, of selective social choice, and of social pressure could not then be handled by statistical methods. It is becoming possible now to state and solve them quantitatively by employing the new methodical devices to which brief reference has been made. For example, Professor Benini, of Pavia, has demonstrated that it is a comparatively simple matter to measure a phenomenon seemingly so elusive as the consciousness of kind. Tabulating the Italian statistics of marriage, he ascertains how many bachelors would marry maidens, how many widowers would marry widows, how many men of a given age class would marry women of the same age class,

how many men of a given nationality would marry women of the same nationality, how many catholics would marry catholics, how many men following a given occupation would marry women whose fathers followed the same occupation, if all of these combinations happened strictly by chance. Comparing the probable numbers with the actual selections, he obtains index numbers of selective choice or preference, thereby determining the exact intensity with which, as Empedocles remarked, "like desires like." This method is applicable to a wide range of social choices.

By a somewhat different procedure it is possible to measure social pressure. In modern times social pressure is definitely distributed through provisions of statute law, and these admit of tabulations from which index numbers can be obtained. By means of varying index numbers, we shall presently measure the varying degrees of social pressure as we now measure changes in the purchasing power of gold. It is hardly too much to say, therefore, that all of the chief theorems of sociology probably admit of quantitative statement, solution and correlation.

In this all too hasty survey of sociological problems and methods, certain provisional conclusions have been indicated. But for the moment they seem to involve us in new difficulties. Apparently, they present curious contradictions. Mr. Spencer tells us that in society, as in aggregates of inorganic things, the character of the units determines the character of the mass, and daily observation affords many seeming confirmations of this view. The collective behavior and the agreeing purpose of a thousand German-Americans, or Italian-Americans, are not altogether like the collective behavior and the agreeing purpose of an equal number of descendants of New England Puritans under like circumstances and in the same en-

vironment. On the other hand, Plato and a long line of later philosophers assumed without question that the character of the mass determines the quality and the conduct of its component units. This assumption is borne out by the biological conclusion that environment moulds the organism, and it is the postulate of both our educational policy and our legislation. That each proposition is true within limits we may perhaps infer from parallel phenomena in the physical world. The geologist tells us that rock which is so highly crystalline that it inexorably determines the character of any structure built of it, may, nevertheless, become wax-like under pressure. In like manner, the harshly individualistic character of the frontiersman determines the scope and the quality of the elementary social relations which are sufficient for his need; while in the dense human mass of a great metropolis, with its traditions and conventions, its municipal ordinances and its highly organized police power, the individual becomes plastic and conformable. Some traits of individuality are lost, and the traits of a type, or class, appear.

The causation is obvious. As social evolution transforms the frontier into villages and towns, and draws population from these to the metropolis, it converts environmental into social pressure, which compels the human units of the community to conform their characters and their lives to a social norm. But now another antinomy appears. Sociology confirms the teaching of biology that individuation is a function of liberty, of freedom and occasion to vary from type; and society constrains. Yet society, notwithstanding its constraining power, on the whole diminishes the sacrifice of the individual to the race, enlarges liberty and heightens individual life.

The problem again is one of limits, but in this case it is one of new factors also. While environmental pressure tends always to increase social pressure, the relation is not

unvarying. The physical and the mental composition of the population affect the ratio. Homogeneous communities are normally democratic. Highly heterogeneous communities, until they attain a very high level of moral and intellectual development, normally evolve coercive authority. The Quaker congregation needs not even a priest. The Roman Catholic communion, embracing all sorts and conditions of men, is governed by the hierarchy. The New England town can manage its affairs in town meeting. New York City is ruled by Tammany Hall.

In this relation of demotic composition to social pressure lies the real importance of those practical questions pertaining to immigration and its restriction which now interest the American people. Homogeneity need not disappear, and social pressure need not increase to the point of despotism if assimilation rapidly transforms the heterogeneous invaders. Liberty can be preserved and extended even under an increasing environmental pressure, so long as society continues to be creative not only of social pressure, but also of its strictly characteristic product—a people—in the sociological sense of the word.

As the sociologist views it, a people is not merely a middle class, or a lower class, in an economic stratification of the population. Much less is it that rabble of the ignorant and the lawless which bulks in the aristocrat's imagination. A people is a psychological middle class between the arrogant and self-sufficient at one extreme, the rude and vulgar at the other extreme. A people is composed of the considerate, which is to say, of those who have both manners and ideas. It is that part of a population which can lay some claim to mental and moral unity, which can do things collectively, which has, in a word, common purposes backed by social instincts and habits. Cicero defined it perfectly. By a people, we are to understand, he said, "not every group of human beings, however brought together, but a

multitude united by a common sense of right and by a community of interest.”¹

Not yet, however, are we at the end of complications and of seeming contradiction. The nation that should adopt the policy of absolute exclusion of alien elements might lose thereby more than it could gain. We have seen that well-being depends upon the ratio of stimulation to pressure, and that stimuli are multiplied by social contacts. Who would venture to estimate the amount of well-being that has come to this American nation by reason of that broadened outlook upon the world, that swift play of mind upon mind, and that true understanding of man by man which are ours because our gates have been held open to our kindred of all lands?

Once more, then, our problem is seen to be one of limits, within which a given effect of social forces may be anticipated. And because this is the nature also of those practical problems with which statecraft has to do, we discover the possible practical value of theoretical sociology as a scientific criticism of public policy. Sociology has been ridiculed as a science which formulates in forbidding terminology the obvious conclusions of common sense. The jibe is an old one, and each science in its day has inherited it. By common sense men could build a bridge that would sustain a given load, but they would waste material. Common sense does not tell the engineer what cross-section his girders must have both to carry the load desired and to insure his retention as a fit adviser to an economical corporation. Under the pressure of external forces, either military or economic, nations adopt policies of unification, which often are extreme and unnecessarily costly in many ways. Reacting from these, they relax the social pressure not only on the socialized and self-controlled, but also on the unscrupulous exploiter and the predatory criminal. It

¹ “De Republica,” I, 25.

will be possible to subject these empirical policies to a rational criticism when sociology has provided us with approximately accurate measures of social forces, and of the correlation between social pressure and both the concentration and the composition of the population. Upon the success or failure of our attempt to obtain such measures will depend the possibility of knowing certainly what policies under given conditions further human progress, and what retard.

Just one constructive criticism sociology, imperfect and tentative as it yet is, may venture to offer now. The democratic movement is in full swing in all the western lands, the constitutional movement in all the eastern lands. Each reveals and measures the so-called power of the masses. The demand is for objective equality—equality of rights and of liberty, of opportunity, and of all those conditions which are created and imposed by society, in distinction from the purely personal qualities, talents and dimensions in which men will forever be unequal. This movement will destroy many cherished institutions; it will level privileges that are dear to men to whom much has been given and from whom little has been required. Democracy will doubtless govern crudely, and it will make grave mistakes, until, in our impatience, we shall cry: "Give us back the rule of the gifted and the wise!" But not by its failures, not by its mistakes alone, shall democracy at the last be judged. Nor should it be judged only by its power to lift burdens from the oppressed. Whatever their composition and whatever the impact of environing forces which they must resist, the nations will be free when intellect has mastered passion, and men are just at heart. The goal of mankind is neither a leveling of those distinctions that inhere in mind and soul, nor yet the exaltation of a ruthless superman; it is the evolution of a super-mankind. And this evolution, like all the evolution of the ages through

which man has groped his way, must proceed through the interaction of organism and environment. If, then, the masses of men are to be enlightened and made just, the outward conditions to which their lives will be conformed must themselves embody justice and must nobly provoke the mind. To create such conditions is democracy's great task. To establish them throughout the earth is the goal of social evolution. For it is also genetically, as it is ideally true, that righteousness exalteth a nation.

PHILOSOPHY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
MARCH 4, 1908**

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Set up, and published March, 1908.



PHILOSOPHY

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PRESIDENT OF COLUMBIA UNIVERSITY

New York

THE COLUMBIA UNIVERSITY PRESS

1908

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ONE of the most famous books ever written, and one of the most influential—the *Metaphysics* of Aristotle—opens with this sentence: “All men by nature are actuated with the desire of knowledge.” This desire of knowledge and the wonder which it hopes to satisfy are the driving power behind all the changes that we, with careless, question-begging inference, call progress. They and their reactions upon man’s other wants and needs have, since history began, wholly altered the appearance of the dwelling place of man as well as man’s relation to his dwelling place. Yet the physical changes are insignificant, great and numerous as they are. The Alps that tried the endurance of Hannibal are the same mountains that tested the skill of Napoleon. The sea that was beaten by the banked oars of the triremes of Carthage, presents the same surface and the same shores to the fast-going, steam-driven vessel of to-day. But the air, once only a zephyr or a hurricane, is now the bearer of man’s silent message to his distant fellow. The crude ore once deeply hidden in the earth, has been dug and drawn and fashioned into Puck’s girdle. The words that bore the deathless verse of Homer from bard to a group of fascinated hearers, and with whose fading sounds the poems passed beyond recall, are fixed on the printed page in a hundred tongues. They carry to a million eyes what once could reach but a hundred ears. Human aspiration has cast itself, chameleon-like, into the

form of noblest verse, of sweetest music, of most moving oratory, of grandest painting, of most splendid architecture, of serenest reflection, of freest government. And the end is not yet.

The forces—the desire for knowledge and wonder—that have so moved man's world, and are so moving it, must be treated with at least the respect due to age and to great achievement.

The naïve consciousness of man has always told him that the existence of that consciousness and its forms were the necessary framework for his picture of himself and his world. Long before Kant proved that *macht zwar Verstand die Natur aber er schafft sie nicht*, man had acted instinctively on the principle. The world that poured into his consciousness through the senses, Locke's windows of the soul, was accepted as he found it, and for what the senses did not reveal man fashioned explanations in the forge of his imagination.

The unseen powers of heaven and earth, of air and water, of earthquake and thunderbolt, were like himself, but greater, grander. They had human loves and hates, human jealousies and ambitions. Behind the curtain of events they played their game of superhuman life. Offerings and gifts won their aid and their blessing; neglect or disdain brought down their antagonism and their curses. So it was that the desire for knowledge and the wonder of man made the mythologies; each mythology bearing the image of that racial facet of humanity's whole by which it was reflected. The *Theogony*, ascribed to Hesiod, shows the orderly completeness to which these mythologies attained.

The mythologies represent genuine reflection and not a little insight. They reveal man's simple, naïve consciousness busying itself with the explanation of things. The

mythologies were genuine and their gods and their heroes were real, by every test of genuineness and reality known to the uncritical mental processes which fashioned them.

Change and decay, growth, life and death, are the phases of experience that most powerfully arouse man's wonder and stimulate his desire to know. Where do men and things come from? How are they made? How do they grow? What becomes of them after their disappearance or death?—these are the questions for which an answer is sought. The far away Indian in his Upanishads cried out, "Is Brahman the cause? Whence are we born? Whereby do we live, and whither do we go? O, ye who know Brahman, tell us at whose command we abide, whether in pain or in pleasure!" To these questions the mythologies offered answers which were sufficient for long periods of time, and which are today sufficient for a great portion, perhaps by far the greater portion, of the human race.

An important step, far-reaching in its consequences, was taken when man first sought the cause of change and decay in things themselves and in the laws which appeared to govern things, rather than in powers and forces outside of and beyond them. When the question was first asked, What is it that persists amid all changes and that underlies every change? a new era was about to dawn in the history of man's wonder and his desire to know. Thales, who first asked this question and first offered an answer to it, deserves his place at the head of the list of the Seven Wise Men of Greece. After Thales the wise men of Greece left off telling tales and busied themselves with an examination of experience and with direct reflection upon it.

It is to be noticed, however, that the evidence of the senses is no longer accepted at its face value. With Thales something new comes into view. It is the systematic search for the explanation of things that appear, with the assump-

tion that the explanation lies behind the appearances themselves and is concealed by them. But as yet, man's gaze was wholly outward. The relation of the nature that he observed to his own consciousness was implied, but unquestioned. Consciousness itself and the knowing process remained to be examined. To turn man's gaze from outward to inward, to change the center of gravity of his desire to know, of his wonder, from nature to man himself, was the service of Socrates. That man is a reasoning animal, that knowledge must be examined and tested by standards of its own, and that conduct must be founded on rational principles, are the immortal teachings of Socrates, as much needed now as when he first unfolded them. They mark him forever as the discoverer of the intellectual life. Of Socrates it may truly be said, in the stately verse of Æschylus,

I brought to earth the spark of heavenly fire,
Concealed at first, and small, but spreading soon
Among the sons of men, and burning on,
Teacher of art and use, and fount of power.

(*Prometheus Vincit*, 109)

The maxim, "An unexamined life is not worth living," is the priceless legacy of Socrates to the generations of men who have followed him upon this earth. The beings who have stood on humanity's summit are those, and only those, who have heard the voice of Socrates across the centuries. The others are a superior kind of cattle.

The intellectual life, once discovered, was eagerly pursued by the two men who have done most to shape the thought of the Western World. For two generations the brilliant insight and noble imagery of Plato and the persistently accurate analytic and synthetic powers of Aristotle poured out for the use of men the rapid results of

wide observation, profound reflection and subtlest intellectual sympathy. For nearly two thousand years the scholars of the world could find little else to occupy them than the problems which Plato and Aristotle had proposed and the solutions which they had offered. The weight of their authority was so great that it prevented the spirit of new inquiry from rising to its feet for a period longer than half of all recorded history.

In a general way, different types of problem were marked off from each other during the whole of this long period of development and study, but the lines of distinction that seem clear today were not often noticed or followed. Questions as to an unseen and superior power, as to logical processes, and as to natural objects and laws were curiously intermingled. Astronomy, mathematics, mechanics and medicine broke off one by one from the parent stem, but it was a long time before the other separate sciences that we moderns know, were able to follow them. Both Plato and Aristotle had indicated the distinction between the different orders of human thinking which is all-controlling, but neither they nor their most influential successors maintained the distinction consistently by any means. So it happened that what we call science, what we call philosophy, and what we call theology were for a long time inextricably mixed. To no inconsiderable extent they remain so today. To disentangle them is the first step toward comprehending what philosophy is and what part it has to play in the intellectual life.

There are three separate stages or orders of thinking manifested by man. At the first stage, the human mind sees only a world of separate and independent objects. These objects are grouped in certain roughly marked visible and audible ways, or by the pleasure or pain, the comfort or discomfort, that they cause; but their likenesses

and unlikenesses and their possible interrelationships are of very subordinate importance. They in no wise limit, alter, or interfere with the separateness of the objects themselves or with what is called their reality. Each elm tree seems a real object, an integer, an independent thing. A falling apple suggests not a universal law of nature but a means of gratifying an individual appetite. Such relations as one of these separate things appears to have, are looked upon as quite secondary, even if they are apprehended at all. This is the stage of naïve, uncritical knowledge. It lies below the horizon of the intellectual life. It is characteristic of the child and of the countless millions of unreflecting adults. It has been dignified by the name common sense. Its proper designation is common ignorance. The intellectual life begins when it is left behind.

At the second stage or order of thinking the world appears as something quite different. Instead of a world of fixed and definite objects whose interrelations are unimportant, the mind now sees that every thing is in relation to every other thing and that relations are of massive significance, indeed that they are controlling. The elm tree, far from being a simple and single unit, is now recognized as an organic form of being, a congeries of cells, of atoms of carbon, of oxygen, of hydrogen, no one of which the unaided human eye can see, much less the untutored human mind grasp. A falling apple no longer suggests merely the gratification of an appetite; it illustrates the laws which bind the universe into coherent unity. So-called common sense is staggered by the revelations that this higher form of knowing presses upon it and insists that it accept, with or without comprehension. It is now seen that no object is independent. Each depends on every other, and dependence, relativity, is the controlling principle of the universe. Under the guidance of Newton, reinforced by the

discoveries of a Helmholtz and a Kelvin, this stage or order of knowing now goes so far as to say that dependence, relativity, is so absolute, that if even the slightest of objects be disturbed in position or altered in mass, the outermost rim of the material universe will be affected thereby; and measurably so, if only our instruments of precision were able for the task. The point of view, the method and the results of this second stage or order of knowing are science.

It can now be seen how little truth there is in Huxley's much-quoted dictum that science is organized common sense. That is precisely what science is not. Science is a wholly different kind of knowledge from common sense, and it contradicts common sense at almost every point. To common sense, the sun revolves about the earth; to science, the contrary is established fact. To common sense, a plank is still and stable; to science it is a huge group of rapidly revolving centers of energy. To common sense, water is a true element; to science, it is a compound of atoms of the familiar hydrogen and oxygen. To common sense, the Rosetta stone is a bit of rock covered with more or less regular markings, probably for a decorative purpose; to science it is the key to a forgotten language and the open door to the knowledge of a lost civilization. Even when common sense recognizes certain simple relations of dependence, it has no realization of their meaning and it is without the power of analysis needed to climb to the higher plane of science. Here rule the stern laws that scientific knowing has discovered in its objects. The laws of cause and effect, of the persistence of force, of the indestructibility of matter—these and their derivatives bring the known world of relations and related objects under their sway. Anxiously, eagerly, untiringly, one field of intellectual interest after another is added to the domain of science, familiar facts are explained by strange

and unfamiliar laws, the obvious and the apparent are traced back to hidden and indeed invisible causes. The human mind, as intelligent, glows with pride at the glad discovery that the nature which invites and tempts it, is intelligible, that it is made in the mind's own image.

At the third stage or order of knowing the world or cosmos appears in still another aspect. It is now seen as Totality. When the world is viewed as Totality there is obviously nothing to which it can be related, nothing on which it can be dependent, no source from which its energy can be derived. We pass, therefore, at this stage of knowing, from the plane of interdependence, relativity, to the plane of self-dependence, self-relation, self-activity. Self-active Totality is the source or origin of all the energies and forces and motions which in one manifestation or another are observed in their interrelations and interdependences by the stage or order of knowing which is science. The unrefuted and, I venture to think, the irrefutable arguments of Plato in the Tenth Book of the *Laws* and of Aristotle in the Eleventh Book of the *Metaphysics*, supported by twenty-five centuries of human experience and the insights of one great thinker, poet and spiritual leader after another, are the foundation on which this third stage or order of knowing rests. Its habit of mind, its standpoint, and its insights are philosophy. Just as science is marked off from common sense and raised above it by analysis and the laws of relativity, so philosophy is marked off from science and raised above it by farther analysis and the laws of self-relation. In proceeding from common sense to science we exchange a chaos of separate units for an ordered whole of interdependent parts; in proceeding from science to philosophy we exchange the working hypotheses of the understanding for the guiding insights of the reason.

There are those, however, who offer stubborn resistance

to the proposal to pass from the second stage or order of knowing to the third, from science to philosophy. They protest that they are invited to pass from clear day-light into a fog, from accurate and easily-tested knowledge to participation in a mock battle with meaningless words. They recall the sterility of science until observation and experiment were set free from the trammels of authority and tradition, and they are fearful lest new and still more irksome bonds will somehow be put upon them. Yet these objectors are not worried about the Infinitesimal Analysis or the Calculus of the Infinite. They allow the mathematician to speak unmolested of the "eyeless observation of his sense-transcending world." They view without alarm the statement of the physicist that "the ether, electricity, force, energy, molecule, atom, electron, are but the symbols of our groping thoughts, created by an inborn necessity of the human mind which strives to make all things reasonable." To this the student of philosophy says Amen!—and rests his case.

That inborn necessity of the human mind which strives to make all things reasonable creates both science and philosophy. To think the world as Totality is a necessity of clear and adequate thinking about anything. To deny this, does not escape from philosophy. It is only to substitute a certainly bad philosophy for a possibly good one. To refuse to admit Totality is merely to adhere to a concept of Totality which is negative.

It is also urged that science is false to itself if it admits a region or realm into which it does not or may not penetrate, that to exclude science is to enthrone mystery. Just so the naïve human consciousness might urge, for the finality of its point of view, that the elm tree is a real unit, that the sun does move around the earth, that water is a genuine element, for the senses tell it so, and that to refuse to believe the evidence of the senses is to throw down the one

sure barrier between the real and the unreal. The answer of science is simple enough. It replies that it does not deny the evidence of the senses, but only inquires what is really involved in that which the senses report. So philosophy, far from being at war with science, accepts its point of view and its results, and asks what do these involve and imply? There is certainly no region or realm into which science does not or ought not to aim to penetrate *on the plane in which science moves*. Its error is when it imitates the protest of the naïve consciousness against itself, and appeals from a higher court to a lower one. Science will grow in power and in influence over the minds of men, and clear thinking will be greatly advanced as full realization is had of the meaning of the profoundly impressive words of Lotze: "The true source of the life of science is to be found . . . in showing how absolutely universal is the extent, and at the same time how completely subordinate the significance, of the mission which mechanism has to fulfil in the structure of the world."

In other words, science is a subordinate category. When science offers itself as the final stage or form of knowing, it is guilty of a false quantity, in that it puts the accent, which belongs elsewhere, upon the penultimate.

The history of man's intellectual development is in no small part a record of the relations and interrelations between scientific and philosophic knowing, between science and philosophy. Both had a common historic origin, both have received massive contributions from the same minds. Each has tried in vain to supplant and to dispossess the other. No exercises of the human understanding are so futile as those to deduce or construct an explanation of natural phenomena as interrelated, with eyes and mind alike tight-closed to observation and experiment. This is the meaning of Bacon's much-quoted aphorism: *Natura enim non nisi parendo vincitur*. On the other hand, no

exercises of the human understanding are so pathetically incompetent as those to make the laws governing the inter-related parts serve for self-related Totality.

The fact that the heavy hand of authority made use of philosophy as a weapon to combat science and its pretensions, as science began to grow into self-consciousness, explains much of the antagonism between science and philosophy which has marked the past five hundred years. The fact that men of science have not infrequently regarded philosophy as an outworn form of human superstition, gives ground for an understanding of the contempt for science which representatives of philosophy have sometimes permitted themselves to express.

Today, however, he who wishes may see clearly that each, science and philosophy, has a field of its own, that both are necessary to the completeness of the intellectual life, that the sure advance of either is a source of strength to the other, and that the more stupendous their achievements the more impressive the rationality of the universe is seen to be.

Philosophic thinking presents difficulties peculiar to itself because by its very nature it must dispense with the aid of images or mental pictures. It deals with concepts. Much irrational criticism of philosophy and not a little bad philosophy are directly traceable to the confusion of images and concepts, of imagination and conception. The statement that a given thing is inconceivable, that it cannot be grasped in thought, will usually be found to mean that it is unimaginable, that it cannot be pictured. Herbert Spencer falls into this error at a critical point in his argument. This initial error and his unquestioning acceptance, through lack of knowledge of Kant, of Hamilton's and Mansel's grotesque application of a portion of Kant's teachings, cause Herbert Spencer's splendid work for the

coördination and synthesis of the sciences to fall short of being philosophy at all. The more acute-minded Bishop Berkeley made the same error in regard to images and concepts, and thereby failed to advance philosophy as his great natural powers so well qualified him to do.

The beginner in the study of geometry is taught the distinction between the concept of a triangle and its image or picture. He uses in his demonstration of the properties of a triangle only those characteristics of the particular figure that he draws or makes, which are common to all triangles. Neither the length of the sides nor the size of the angles is taken into account. His demonstration would hold good if a triangular figure of any other sort or size were substituted for that which he is using. The particular figure or image is only a symbol of the concept triangle; it has no significance of its own. The concept, triangle, is the essential thing. It is the rule or definition according to which all particular triangles, or images of triangles, are made, whatever the length or disposition of their sides or the size of their angles. To grasp this distinction between concepts and images and to comprehend the relation between them, is essential to philosophic thinking of any sort. For example, the image, water, is a mental picture of some particular appearance of water. It may perhaps be the rolling and turbulent ocean, a placid lake, or a tumbling mountain brook. The concept, water, includes the rising of moisture from earth or sea, its gathering into clouds, its condensation into falling rain, its pools, its streams, its great lakes and seas; its hardening into ice at one temperature, its passing off in steam at another; its composition of hydrogen and oxygen; its every manifestation and characteristic. The concept brings to mind that process, that transforming energy, which restlessly reveals itself now in one form or mass of water, now in another. It deals with that which persists when any given form or manifesta-

tion of water passes away. The concept represents the process, the energy, which is at hand whenever and wherever water appears; the image represents a particular and transitory appearance.

When this point is reached the student of philosophy is really beginning to think. He has laid the foundation for a standard of values, for judgments of worth as distinguished from judgments of fact. He has caught sight of the real difference between the permanent and the transitory.

Philosophic knowing, like scientific knowing and the uncritical knowledge of the child, is compassed about by the forms of consciousness, and its results like those of science are cast in these forms. Above and outside of these forms no knowing can by any possibility go. The suggestion is sometimes made in serious fashion that before consciousness was developed, the nature and appearance of the world were of certain kind. The statement is not only unimaginable, but inconceivable as well. The words mean nothing. An instant's reflection shows that consciousness, which has supposedly not yet been developed, is peeping from behind a curtain in yonder cloud to see how the world is getting on without it. The world is in and for consciousness, and no possible juggling with words can shake this final foundation on which all our knowing, of every kind, is built. Put consciousness out of the door and it is instantly back through the window. This explains why philosophy interprets in terms of will—the name for the only energy that consciousness knows directly—the energy which so abundantly and so marvelously manifests itself on every hand in nature and in history. The conscious effort of moving the hand, the head, the eye, is the type and norm by which we interpret, as the results of energy, the changes of position and of mass which we so incessantly observe.

The concepts of force and energy are of necessity referred to the concept of will as their explanation. Moreover, in the course of the development of the forms of life we find irritability, a form of energy which we must interpret in terms of will, long before we find anything approaching a manifestation of intelligence. Intelligence appears either as a later development out of will, or as a graft upon it. A weighty group of modern physicists believe that matter itself, in its ultimate state, may be analyzed into energy, which again is only humanly explainable as will.

A strong, and in my view, the dominant tendency in philosophy, powerfully supported by the results of scientific knowing, is that which sees Totality as energy, which is will. Perpetual motion is clearly impossible, from a mechanical point of view, at the scientific stage of knowing. Just because of this fact, all mechanical motion can only be explained as having originated as will-force. This will-force is self-active Totality. The ethical and the metaphysical, as well as the theological results and implications of this conclusion, are of the first order of importance.

There is, I venture to think, no ground for the ordinarily accepted statement of the relation of philosophy to theology and religion. It is usually said that while philosophy is the creation of an individual mind, theology or religion is, like folk-lore and language, the product of the collective mind of a people or a race. This is to confuse philosophy with philosophies, a common and, it must be admitted, a not unnatural confusion. But while *a* philosophy is the creation of a Plato, an Aristotle, a Spinoza, a Kant, or a Hegel, philosophy itself is, like religion, folk-lore and language, a product of the collective mind of humanity. It is advanced, as these are, by individual additions, interpreta-

tions and syntheses, but it is none the less quite distinct from such individual contributions. Philosophy is humanity's hold on Totality, and it becomes richer and more helpful as man's intellectual horizon widens, as his intellectual vision grows clearer, and as his insights become more numerous and more sure. Theology is philosophy of a particular type. It is an interpretation of Totality in terms of God and His activities. In the impressive words of Principal Caird, that philosophy which is theology seeks "to bind together objects and events in the links of necessary thought, and to find their last ground and reason in that which comprehends and transcends all—the nature of God Himself." Religion is the apprehension and the adoration of the God Whom theology postulates.

If the whole history of philosophy be searched for material with which to instruct the beginner in what philosophy really is and in its relation to theology and religion, the two periods or epochs that stand out above all others as useful for this purpose are Greek thought from Thales to Socrates, and that interpretation of the teachings of Christ by philosophy which gave rise, at the hands of the Church Fathers, to Christian theology. In the first period we see the simple, clear-cut steps by which the mind of Europe was led from explanations that were fairy-tales to a natural, well-analyzed, and increasingly profound interpretation of the observed phenomena of Nature. The process is so orderly and so easily grasped that it is an invaluable introduction to the study of philosophic thinking. In the second period we see philosophy, now enriched by the literally huge contributions of Plato, Aristotle and the Stoics, intertwining itself about the simple Christian tenets and building the great system of creeds and thought which has immortalized the names of Athanasius and Hilary, Basil and Gregory, Jerome and Augustine, and which has given

color and form to the intellectual life of Europe for nearly two thousand years. For the student of today both these developments have great practical value, and the astonishing neglect and ignorance of them both are most discreditable.

The student of philosophy is more fortunate than some of his contemporaries in his attitude toward the period called the Middle Ages.

The very use of the name Middle Ages to describe a group of ten centuries is sufficient evidence that those centuries are neither understood nor appreciated. The modern world at the time of its beginnings reacted so sharply and so emphatically against the methods and ideals which had guided the civilization of the centuries that went before, that for the time being the laws of evolution were forgotten and the attempt was made to break completely with the past and to begin the history of civilization anew. The student of philosophy, however, finds in the so-called Middle Ages a rich field for study and contemplation. He sees there the mind of modern Europe at school. It is learning to think and to use the tools of thought. It is sharpening and refining language, and the nations that are to be are making each a language of its own. The view of life which Christian theology then taught with marvelous uniformity was working its way into the consciousness of those Northern peoples who had both overthrown the Roman civilization and been overwhelmed by it, and was the controlling power in their lives.

To suppose that such an age as this can be properly described as dark, is only to invite attention to the limitations of one's own knowledge and sympathy. No age was dark in any true sense that witnessed the assembling of scholars at the feet of Alcuin and Hrabanus Maurus, that saw the rise of universities, of guilds and of cities, that was fired by the enthusiasm and the zeal of St. Dominic and St. Fran-

cis, that gave birth to the story of the Cid, of the Holy Grail, of the Nibelungen Lied, and the divine comedy of Dante, that witnessed those triumphs of Gothic architecture that still delight each eye that rests upon them, or that knew the Constitutions of Clarendon, the Magna Charta and the legal Commentaries of Bracton. Such an age as this is perhaps not one with which any century since the 17th stands in close sympathy, but it is neither a dark age nor a middle age. It has significance and value of its own. It witnessed the preparation of the mind of Europe for what was to come, and it is not poor but rich in evidences of culture and reflection. This is particularly true in the domains of philosophy and of literature. The student of philosophy does not overlook this fact.

Any study of philosophy that is worth while will lay strong emphasis on a knowledge of the historical development of philosophic thought. It will dwell upon the influence of philosophy upon the activities of men, from the time of its crude beginnings by the shores of Virgil's

—Salis placidi vultum fluctusque quictos

to the crowded, hastening, electric-bound world of today. For the history of philosophy is in fact, as Professor Ferrier once said it was, "philosophy itself taking its time, and seen through a magnifying glass." Against the background of the centuries man's efforts to grasp and to explain Totality, of which he is a part, stand out in splendid illumination. The two greatest and most enduring achievements are easily seen to have been the work of the Greek and the German minds. The cosmological method of the one and the psychological method of the other, when brought together in synthesis, offer us the deepest insights of which humanity has yet been capable. The Greek and the German languages are the most adequate to the expres-

sion of philosophic thinking, for the reason that these languages mirror the powers and characteristics of the racial groups that brought them into being. In making their weighty contributions to philosophy, the Greek and the German peoples evolved language-forms competent to give expression to their profoundest thoughts. Their four chief representatives—Plato, Aristotle, Kant, Hegel—tower, like mountain peaks above the plain, over all others who have given voice, in systematic form, to man's highest intellectual aspirations. St. Augustine, St. Thomas Aquinas, Spinoza, and perhaps also Descartes, follow a little distance behind. No others have climbed so far up the Hill Difficulty as these.

To grasp in fullest significance the movement of contemporary thought, and to pass judgment upon it with some approach to a proper sense of proportion, the student must know his Kant. Max Müller's phrase was a good one: "Kant's language is the *lingua franca* of modern philosophy." It is not too much to say that without an understanding of Kant the door to a just appreciation of modern thought is closed. The reason for this judgment is that the adequacy of most modern thinking is to be tested primarily by the method it pursues, and Kant is the great reformer of philosophical method. One may watch the justly emphatic Empiricism of Bacon march straight forward to its logical conclusion in the almost unlimited Scepticism of Hume. On the other hand, one may see clearly enough how the rationalistic method which commended itself to Descartes developed of necessity into the full-fledged and all-inclusive Dogmatism of Christian Wolff. The two conflicting methods, Empiricism and Rationalism, resulted, at the end of something more than a hundred years, in two mutually contradictory sets of conclusions, Scepticism and Dogmatism. Each might abuse the other,

but neither could refute the other. An absolute deadlock was presented by the thought of the 18th century as it found expression on the one hand chiefly in England, and on the other hand chiefly in Germany. To break this deadlock there was need of some new method which could mediate, so to speak, between the extremes of Empiricism and Rationalism. That method is the critical method of Immanuel Kant. The story of his own intellectual development, the steps by which he climbed up from one point of view in philosophy to a higher and more inclusive one, until finally he produced the *Kritik der reinen Vernunft*, is one of the most instructive and illuminating in the whole history of human thinking. The student who has really come to an understanding of Kant, his method, and his contribution to philosophy, is ready for any task that reflection can put upon him.

It is said of Kant that he used to tell his students at Königsberg that he sought to teach them, not philosophy, but how to think philosophically. This view of the teaching of philosophy, which I hold to be the correct one, is the reason why students of philosophy, particularly beginners, should concern themselves with the works of the genuine masters of philosophic thinking, and not waste their time and dissipate their energies upon the quasi-philosophical and the frivolously-philosophical writing, chiefly modern and largely contemporary, which may be not inappropriately described as involving Great Journeys to the Homes of Little Thoughts!

The clever intellectual posing and attitudinizing of Nietzsche, whose body and mind alike were sorely stricken with illness, is only a travesty upon philosophy. The curiously barren efforts of Haeckel, when he leaves the field of science in which he is an adept, are but little better. Even the form of philosophy called Pragmatism,

for which the great names of Oxford, Harvard and Columbia are academic sponsors, and which when unfolded to the man in the street leads him to howl with delight because he at last understands things, should come late and not early in a student's philosophical reading. A background of considerable philosophical knowledge will aid in giving to it a just appreciation. There are critics who have the fear that Pragmatism, in its attempt to be both profound and popular, may, forgetful of the ancient warning of Plautus, suffer from attempting to blow and to swallow at the same time.

The English and American student of philosophy is in no small measure handicapped by the fact that there is so little genuinely first-class philosophical writing in the English language. The Anglo-Saxon and Anglo-Celtic people have expressed themselves in much noble poetry and in political institutions of the greatest value and importance, but their positive contributions to constructive philosophical thinking have been meager. They have at times offered the obstacle of sharp criticism and unsatisfied scepticism to the progress of obscure, extreme and unsound tendencies in philosophic thinking, but the stones that they have laid upon the permanent structure of philosophy are few. Of writers in English during the last decades of the 19th century, the two Cairds, the two Wallaces, Green and Harris stand almost alone in their ability to reach really exceptional heights in the task of philosophic criticism and interpretation. They have all enjoyed the advantages of what is so conspicuously lacking in most contemporary writing on philosophy, namely, broad and deep philosophical scholarship. After the human race has been at work on its chief problem for thousands of years, the man who ignores all that has been accomplished and is consumed with an ambition to be original, is pretty certain to end by being simply queer.

It would be a grateful task, did opportunity offer, to point to some of the conclusions of philosophy which seem to me to be the surest: to show that nothing less than an eternal moral order will satisfy our deepest human needs or our loftiest human aspirations, an eternal moral order which is the final test of all theories and explanations; to urge the significance of the testimony of the human heart to our dependence on a higher power, testimony voiced alike in the opening verses of the poem of Lucretius written while Cæsar lived and Tully spoke, and in the sweet and tender music of Cardinal Newman's *Lead, Kindly Light*, of Lord Tennyson's *Crossing the Bar*, and of Rudyard Kipling's *Recessional*, testimony recorded boldly and ineffaceably in the countless sainted lives that have been lived on this earth; to read the lesson of man's unconquerable optimism, his

—trust that somehow good
Will be the final goal of ill

which, despite all temptations, has thus far kept him from framing any scheme for education, politics or society upon the hypothesis that the influences making for evil in the world will finally conquer; to make plain the full meaning of the dictum of Hegel that "the whole of philosophy is nothing but the study of specific forms or types of unity," and to illustrate the principle of Spinoza that "a thing has only so much reality as it possesses power"; to bring evidence to prove the fact that philosophy does for the thought which combines and unifies things what science does for the facts or things combined and unified; to trace the hand of philosophy in architecture, in painting and sculpture, in poetry and in the political and religious institutions that mankind has made; to follow down the course of events in the Western World and to illustrate how true is the saying of Thucydides that history is philosophy

learned from examples; to indicate the close relations between philosophy and the logic which is mathematics, relations felt or suspected by Pythagoras and Plato, by Descartes and Spinoza, by Leibnitz and Kant, and to suggest ways in which mathematics can and does lead from science to philosophy and binds them together; to reveal the laws of evolution as significant and vital principles in philosophy long before the sciences of nature discovered and proved the existence of the same or similar laws in their own sphere; to throw light upon the deepest cleavage known to history—that between Orient and Occident—by contrasting the civilization based upon a philosophy that cannot account for or explain independent individuals, that holds any appearance of such to be Maya, illusion, and that longs for return to and absorption in Nirvana, with that civilization which is based upon a philosophy that does account for and explain independent individuals, and that calls on them to exert and develop themselves to the utmost in order to approach nearer to intellectual and moral perfection. All this, and much more, philosophy endeavors to teach.

More than seventy years ago De Tocqueville expressed the opinion that in no country in the civilized world is less attention paid to philosophy than in the United States. At that time he was right, but, fortunately, he is right no longer. Philosophy is now vigorously prosecuted among us. Wordsworth's "years that bring the philosophic mind," are bringing it in some measure to us. We must cultivate and encourage that philosophic mind, for we are sorely in need of it to bring unity into our knowledge, to install securely principle in the judgment-seat before which conflicting practices are the contentious litigants, to gain a sense of proportion and a point of view in the study of history and of nature, and to set final foot on the head

of the dragon Philistinism that everywhere assails worth in the name of "that which works." Perhaps we may venture even to cherish the hope that, in Victor Hugo's well-known phrase, *Ceci tuera cela!*

We need philosophy, too, to aid us to gain that even mind in things severe that Horace counsels, and to help us to see life steadily and see it whole, as Matthew Arnold sang of Sophocles. The modern world has sat at the feet of the ancient world for a long time, but it has not yet learned all that the ancient world has to teach.

To carry into science and philosophy the presuppositions of uncritical knowledge is to lead ourselves into curious vagaries and contradictions, unless we can rise above or outgrow such presuppositions. Education is in no small measure preparing the way for the intellectual life and pointing to it. Those who cannot enter in at its gates are doomed, in Leonardo da Vinci's words, to "possess neither the profit nor the beauty of the world." For them life must be short, however many its years, and barren, however plentiful its acts. Their ears are deaf to the call of the indwelling Reason and their eyes are blind to all the meanings and the values of human experience. Where there is no vision, the people—and the university—perish!

PSYCHOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
MARCH 11, 1908**



PSYCHOLOGY

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New York ,
THE COLUMBIA UNIVERSITY PRESS
1908

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Set up, and published April, 1908.

PSYCHOLOGY

IN attempting to give a view of the present state of his science—a view that shall be fairly objective and free from the bias of his own particular interests—the psychologist encounters a peculiar difficulty in that the camp of his fellows is divided. Two standards are displayed; two parties are in the field; and their relations are not always so friendly as might be expected of soldiers in a common cause. Such divisions are indeed not unknown in the other sciences. The descriptive and the dynamic phases of a subject, the study of structure and the study of function, frequently divide the workers between them, and sometimes those who hold to the one despise the other. The line of cleavage is sharper in psychology than elsewhere: those who define psychology as the science of consciousness—the “morphology of consciousness,” as one has put it—maintain that any study which does not contribute to the description of conscious life lies beyond the pale of the science; whereas to those who define it as the science of those functions of the organism which are roughly designated as *mental*, the examination of the consciousness attending these functions, though valuable and suggestive, does not lie at the root of the matter. This strife is indeed carried on more at the level of theoretical discussion than at that of practical investigation, for those who work at special problems are apt to approach them from both sides.

There are then two general problems of psychology, and

two general methods, one appropriate to each problem. Consciousness affords a rich variety of phenomena, which tempt the scientifically inclined observer to describe and classify them. Even as the variety of plants, with their gradations of likeness and difference, led the naturalist to descriptive and systematic botany, so the multitude of sensations and emotions, of memories and fancies, thoughts, desires and decisions was sure, in time, to entice those who were gifted both with scientific curiosity and with a self-observant temper into an effort at setting down these multifarious appearances in some kind of order. The method appropriate to such studies was imposed by the nature of the case. As we can not enter directly into the consciousness of our fellows, each observer must examine his own, by introspection. And not all self-observation is entitled to be called introspection. Since a thing can be observed only when it is present, the observer of conscious facts must have those facts within him at the moment of observation. He must serve simultaneously as the observer and as the generator of the thing observed. This creates a difficulty for the introspectionist which is practically very great, and theoretically insurmountable. Comte went so far as to assert that it made psychology impossible. The subject and the object of an observation can not be the same, he said. I can not divide myself into two persons or agents, one of whom does something which the other notes. And without such a division, self-observation is impossible, for if I do anything, I am occupied with doing it and not with observing it, whereas if I set myself to observe, there is nothing doing to be observed.

The antinomy of the introspective method is however not quite so sharp in practise as the philosopher has asserted. If it were, you could not even state with confidence that the speaker's voice was audible to you. And much more than this is possible. You can be sure whether the word

“antinomy” gave rise in you, a moment ago, to a prompt feeling of recognition, or to some hesitancy and disaffection towards the speaker. That introspection is to some degree possible arises from the fact that the consciousness of a moment is not an indivisible unit, but has parts. More than one process may simultaneously go on in it, and one of the simultaneous processes may consist in observation. Some persons frequently have the feeling of a division within them, one part being engaged in watching what the other is doing.

But the difficulty of introspection is only half overcome by this doubleness of consciousness, for the processes that go on simultaneously are not without influence on each other; they often interfere with each other's completeness and efficiency. If the process to be observed is easy and the observation also easy, little confusion need result; but when the process to be observed is complex or absorbing, as in the case of an emotion or difficult task, it becomes hard to maintain the attitude of the scientific observer; and in so far as the observer's attitude is maintained, it is doubtful whether the other process runs its normal course. Thus the introspective psychology of the emotions is more properly the psychology of the emotions while psychologizing.

Some help comes to us here from the existence of a “primary memory,” from the readiness with which an experience can be recalled before it has fairly passed out of consciousness. Just as the words of a speaker linger for a while, and may, as it were, be forcibly haled back before they are fully gone, to receive more careful attention than they got at first, so even a poignant emotion may suggest, as it starts to fade away, that here is the opportunity, so long desired, of making an interesting observation. Such a suggestion would hardly occur to anyone but a psychologist, and not to him as often as might be desired.

In spite of these mitigating circumstances—the possi-

bility of two simultaneous processes in consciousness and of primary memory—the case of introspection is a hard one, and many, even psychologists, are disposed to regard its results as seldom reaching the standard of scientifically observed facts.

When, in the middle of the last century, a few psychologists believed the time had come for the introduction of experiment, they did not aim to substitute a new method for that of introspection, but to provide conditions under which introspection could be more precise. One improvement consisted simply in making it first hand, in substituting definite observations for vague impressions derived from past experience. The older psychology—distinctly an armchair science—had been in reality less introspective than retrospective. The net result of past experience had been relied on, and no need had been felt for going back to the individual instances. Single observations, recorded on the spot, form the basis of modern psychology. We no longer accept a general conclusion unless we are shown the individual recorded instances on which it rests.

Along with recorded observations go repeated observations. The variability of conscious events is so great that it is never safe to depend on single instances. For a similar reason, it is now felt to be unsafe to rely on the introspection of a single observer. In the earlier days, which now seem to us days of happy, easy confidence, when the psychologist had made an observation on himself, he said, not “I do so and so,” but “We do so and so,” never doubting that other minds would do the same as his. Such confidence is now known to be misplaced. The varying self-observations of many minds must be collated, and their agreements, if any, separated out from the mass of disagreement, before arriving at a description which shall have a claim to universal validity.

These reforms have made introspection more conscientious.

tious, and necessity has also made it more modest. It can not hope to grasp the whole of a conscious event in a single observation. The attention of the observer must be focused on some definite and often minute point. He must not attempt to describe his experience in full, but to answer the simple question, "Do you observe this—yes or no?" Such observations are minute, microscopic almost, and attempts are made to make them genuinely microscopic in some such way as the following. Besides the observer, in whom the conscious process is to be aroused, a second person is present as the conductor of the experiment, a sort of stage manager. He prepares the apparatus and other externals, and sets the observer some task, such as the comparison of two physical stimuli as to their intensity, duration, pleasureableness; or it may be some intellectual problem is to be solved. But, instead of letting the observer alone till the task is finished, he interrupts him in its midst, and questions him regarding the consciousness present at that stage. Now ordinarily, with the naked eye of introspection, we attend so little to the way we feel while performing a mental task, to the consciousness which intervenes between the grasping of the question and the appearance of the answer, that we could give little account of it. By the intervention of the manager of the experiment, it becomes possible to catch some of the fleeting consciousness ere it disappears and so to reveal details which would otherwise remain hidden.

By such devices, introspection can be made to give data of sufficient precision for scientific use; but the data are of a minute and technical sort, and fail to satisfy the natural curiosity of man as to the deeper and higher things in experience—the absorbing emotions or the flights of imagination. In short the complaint is made that experimental psychology is lacking in human interest; and should not psychology, of all subjects, possess human interest? The

psychologist too would wish to rise to these noble themes, but he feels that he could not as yet deal properly with them. He is comforted by the thought that the exceptional may really be less important than the ordinary run of experience, for the purposes of a science of consciousness. As history shows a tendency to descend from the heroic to the routine in the experience of the race, believing that only thus can the past be truly revealed, so psychology, driven largely by the necessities of its method, has already made a similar descent. It might well be expected, therefore, that an inventory of the results of introspective psychology would be rather a dry and technical affair, unsuited to the present occasion. Let me try, however, to set forth a few results which may have some interest. A definition is first necessary. A "moment" in psychology—not necessarily a "psychological moment"—is so much of consciousness as seems to be simultaneously present; the present moment of consciousness is so much experience as is being got now—just now. Formerly, under the influence of physical analogies and of the dogma of the unity and simplicity of the mind, the moment was conceived as a point, a moving point to be sure, and a point that changed in quality as it moved, but a point in time, leaving its past instantly behind it, and a point in breadth, admitting of no simultaneous plurality. Introspection, under experimental control, reveals no such mathematically perfect atom of consciousness. The moment is extended in at least two dimensions. It is extended in time. Absurd as it may seem to speak of the present moment as reaching back a little way into the past and even forward a little into the future, this must not deter us from describing consciousness as we find it. So described, the present moment, though it has a center corresponding somewhat with the mathematical present, contains also a dying away of events that have just passed the center, and

a coming in of events that have not yet reached the center. The shadows which coming events cast before them in consciousness are partly of the nature of expectancies, and partly due to the imperfect perception of events which have already happened but are only beginning to take hold of us. We live a fraction of a second, or more, behind the time, and can never catch up, because time is always needed for a new event to win the center of consciousness from the old event that holds it. The center of the felt present, the thing which most occupies the field, is always a little behind the newest thing in consciousness. Nor does the old event, which gives way to the new, drop instantly out of sight; it lingers, gradually dying away; it remains as something which is passing but is not yet wholly past.

That the conscious moment has another dimension besides its length in time is also clear to introspection. A plurality of items may coexist within it; the contrary doctrine was not founded on empirical observation.

Yet the moment is not a bare sum of discrete items. It shows internal organization. The items are related to each other; they tend to be grouped into wholes. A series of sounds, physically of equal intensity and with equal intervals between them, is not heard as such. Some of the sounds receive a subjective accent, and some of the intervals are subjectively lengthened, with the result that the series seems to have a rhythmic form. So, a jumble of dots on a plain background are seen as if grouped. The grouping may change on continued examination; but, at any one moment, the dots are organized in a certain form. However disconnected the items presented at a moment may be as physical facts, they are almost sure to appear in consciousness as fused, contrasted, grouped or in some way related to each other.

The moment is centered about some item which is tem-

porarily the most prominent; it occupies, as we say, the focus of attention, while other items lie more to the margin of inattention. If one's mind is centered on a speaker's thought, then the peculiarities of his voice or appearance, the appearance of others near him or in more distant parts of the room, extraneous noises, and one's own bodily feelings, may still be marginally present in one's consciousness; though unimportant intellectually, the blend of these obscure components of consciousness has its significance as constituting the emotional undercurrent of the moment.

One moment shades off into another; no exact boundaries appear between them. Their sequence is not like a succession of separate views, but each dissolves into the next. Professor James, in a chapter which is among the most successful efforts at introspective description, discards the old metaphors of a chain or train of ideas as entirely inadequate, and substitutes the figure of a "stream of thought." He also calls attention to the existence of conscious transitions or modulations from one prominent idea to the next, the transitions consisting in a variety of feelings of expectancy and relationship. From all this it will be seen that present conceptions of conscious process differ widely from the cut-and-dried schemes which were current a generation or less ago.

An important result, along quite a different line, came out of Galton's inquiry into the mental imagery of various persons. When he asked them to think of some familiar scene, some reported that a picture of the scene arose within them, and appeared before the mind's eye almost as if present to sense. Others had much less of this pictorial consciousness; still others reported an entire absence of any such thing. Though they recalled the scene to mind, and were prepared to describe it, they did not picture it to the inner sense. The same individual differences appear in the process of recalling auditory,

olfactory and tactile experience. It is the existence of great individual differences in the consciousness of the same facts which gives interest to this result. Men may compare notes regarding what they have experienced, and agree as to the material facts, while nevertheless their modes of being conscious of the recalled facts are extremely diverse.

A number of recent studies of the consciousness attending important mental functions, such as judgment, reasoning and voluntary action, have come to negative conclusions which yet have their value from one point of view. There appears to be no definite sort of consciousness appropriate to each of these functions, no introspective mark or differentia of each. Given the starting point of a mental performance and its outcome, we can not infer what consciousness intervened. This is true even of the simple case, familiar in the laboratory, in which two sense stimuli, one following the other, are to be compared in intensity. The old conception of the process was that when the second stimulus came, an image of the first recurred to mind; the two were held up side by side in consciousness and their likeness or difference read off. Experiment shows, however, that though this is sometimes true, more often the judgment of likeness or difference arises immediately on the presentation of the second stimulus, without any renewed consciousness of the first. Such results show that conscious process is more fluid and less diagrammatic than is assumed by those who work out logical schemes of what it must be. They show too that consciousness can not be known by its fruits. You can not infer what consciousness must be from its objective manifestations, nor even can you, keeping wholly within the stream of conscious events, infer what has gone before from what follows. Each bit of consciousness must be known, if at all, by direct observation.

Facts like these make it seem impossible to employ an objective method in psychology. Many students of the subject, in short one of the two great parties into which psychologists are divided, repelled by the difficulties and the treacherousness of introspection, have resorted to the examination of objective facts connected more or less directly with mental life. Some have gone so far as to assert that only by such means could scientific information regarding the mind be reached. As examples of such studies may be mentioned folk psychology, which examines language, myth and literature, art, customs and institutions, with the object of inferring back from the products of mental activity to the character of the activity. We have also animal and child psychology, which endeavor to deal with minds incapable of reporting introspective observations. Here belongs as well a large part of the work done in experimental psychology, for often the person experimented on does not serve strictly as an observer of his inner consciousness, but has simply to react in some assigned way to a situation which is presented to him. He may have simply to move his finger as quickly as he sees a certain light, or to move his right forefinger when red is shown him and his left forefinger when green is shown him, or he may have to name a presented object as promptly as possible, or answer a given word by another word standing in some assigned relation to it. He is not asked to observe his consciousness during the process, but simply to react. In another line of experiment, the person examined is presented with two weights differing but slightly, and is asked to say which is the heavier. He is not asked to describe the contents of his consciousness during his process of judging, but simply to judge. Or again, in an experiment on memory, he is given a list of disconnected words or syllables, which he studies till he can repeat them in proper order; a day later he is tested to

see how much of the list he retains. He is not asked to describe his subjective experiences while learning or recalling these words, but is merely required to learn and recall them.

Many similar experiments have been carried on in psychological laboratories, and have been received by the introspectionists with no great applause. They denounce the method as unpsychological. "You are not attaining to a description of consciousness by this means," they say; and, in the light of the facts alluded to a few moments ago, they are clearly right. From the examination of a painting, for example, you can not tell what was in the mind of the painter when he conceived his work; it might seem that he must have had before him a mental picture of which the existing painting is a copy; but among the painters who have been asked regarding this, some have denied that such a mental image was present, and even that they had the power of forming a mental image. When we already know a form of consciousness, its objective manifestations, and the regularity of the connection between them, we can of course infer with some degree of probability from the manifestation back to the condition of consciousness. But we must first know consciousness.

From all this it becomes clear why the introspective psychologist accuses the objective psychologist of sailing under false colors. He may be studying something, and doubtless is, since he gets results which display considerable regularity and precision, but he is not studying consciousness, and if psychology is the science of consciousness, he is no psychologist. The introspective psychologist dubs him a "psycho-physicist," or a "gnoseologist," or a sort of physiologist; and mollified by the verbal distinction, goes his way, leaving the objective student to go his. The choice of words need not detain us here. The thing to notice is that a large share of those who call themselves

psychologists are concerned with the facts which can be found by the objective method. Of what nature, then, are these facts? The objective wing has not taken much trouble to justify its position formally; but I think it fair to say, after an examination of the detailed problems which they set themselves, that they are looking for the facts of mental function, that they are seeking the causes and conditions of mental performances, in short that their study is dynamic. They are not trying to describe consciousness, but to unearth the causal relations which obtain among mental performances and between them and their physical conditions and manifestations.

It should be noted that the introspective method has not much to tell of the causal relations of the conscious events which it studies. For one thing, consciousness is not a closed system. Physical stimuli are always breaking into it from outside, and its own processes are constantly leaking away through motor channels. The dynamics of consciousness could no more be discovered by confining attention to consciousness itself than the laws of plant growth could be made out by studying the plant in isolation from the soil, air and sunlight. But, what is rather surprising, consciousness not only fails to reveal the external factors which determine the course of thought, it does not even reveal with any completeness the internal or cerebral conditions of thought, as the following simple experiment illustrates.

Set yourself to add pairs of numbers—the one-place numbers will do as well as any. As each pair is presented, the sum immediately occurs to mind. But now change the problem: set yourself to multiply pairs of numbers; then the appearance of a pair straightway calls up the product. In one case you are 'set' or adjusted for addition, and turn out sums; in the other you are set or adjusted for multiplication, and turn out products. Since the numbers

given may be the same in the two cases, and yet lead to different results, it is clear that the mental adjustment has much to do with your reaching the right answers so promptly. But now interrupt yourself in the midst of such a series of operations, and ask what consciousness you have of this set or adjustment which is causally so important. Usually you will find nothing—nothing, at least, more definite than a feeling of readiness for what is coming—nothing characteristic of the exact problem which you are prepared to solve. And, on the other hand, you may find many things which probably have nothing to do with the mental performance in question—sensations, images and tinges of emotion which only happen to be there at the same time. It is clear that conscious process does not correspond closely with mental process, if by the latter term is meant the process that leads to some mental result—a perception, a recollection, an invention, a preference, a decision, the solution of a problem. He who would trace the dynamic process by which such results are reached can not content himself with the introspective method, though it may indeed give him valuable suggestions.

It is this sort of task which is taken up by those psychologists who use the objective method. The essence of the method consists in arousing a certain type of reaction to a given situation, the conditions being standardized, and the reaction, as far as possible, reduced to quantitative terms. The conditions are now varied in accordance with some definite plan, and the corresponding changes in the reaction are noted. The relation of the changes in response to the changes in the conditions is the important thing. For example, it is desired to discover how the sense of sight, which at first thought seems incapable of giving anything more than two-dimensional pictures, such as might be accurately represented in a colored photograph, nevertheless enables us to judge of the third dimen-

sion, of the distance of objects from us. Introspection does not reveal the factors which determine the judgment. Several possible factors are suggested, as hypotheses are suggested in any science; such as perspective, haze, the presence of intervening objects, and the slightly differing views of the same object which are had by the two eyes. To investigate the importance of intervening objects as a factor in determining the judgment, we remove them, placing the person examined in a dark room with only one spot of light visible, the distance of which he has to judge. We find that he does so very badly; we then restore some of the intervening objects and, finding his judgment improved, we conclude that the presence of intervening objects is a factor in the judgment of distance. Similarly, to examine the importance of binocular vision, we compare the accuracy of the judgment with one and with both eyes; and finding it superior with both,—finding also that the stereoscope, which presents to the two eyes slightly different views corresponding to what each would see in looking at the object, gives a strong impression of solidity and distance,—we infer that the judgment of distance is based largely on this difference between the two fields of view.

It is the task of the dynamic psychologist to devise means by which to control the conditions under which a mental operation is performed and by which to gauge the character and success of the operation. For controlling the conditions a great number of special devices are employed, which can not easily be summarized in a few words. For gauging the success of the operation, measurement can be applied in three ways at least, as to its speed, its accuracy and what may perhaps be called its force or energy. As examples of the measurement of the energy of mental activity may be mentioned the determination of the number of items of a given kind that can

be grasped at a single glance—the number being found to increase greatly when the items are related in easily perceived ways—or of the amount that can be memorized at a single reading. More common are measurements of speed and accuracy. The older classics of experimental psychology are largely devoted to the accuracy of sense discrimination and to the speed of simple mental processes. The speed is valuable as affording an index of the complexity and difficulty of the mental operation.

In recent years, the center of gravity of investigation has shifted from perception to the motor processes and especially to the central processes, such as association, memory and the effects of practise or training. Eye movements, important to psychology because of their connection with theories of space perception and of appreciation of beauty of form, and with the act of reading, have been recorded photographically by psychologists, with rather striking and important results. Many facts are being disclosed regarding the conditions of greatest efficiency in memorizing, and regarding the laws of retention and recall. In the older work, the improvement of a function with practise was principally a disturbing factor, since it created difficulty in the way of comparing repeated observations on the same person. Of late, the practise effect has aroused interest for its own sake. The person tested repeats the same performance time after time under the same conditions, his success being measured. Almost any performance will serve as the subject matter of the experiment, since all improve with practise, though in unequal measure.

The results may be presented graphically in a “practise curve,” which, much after the fashion of the temperature curve of physicians or the curves of barometric pressure and wind velocity put out by the weather bureau, shows the changes in efficiency of the function with the progress

of training. Much might be said of the results of this line of study. If we analyze the lack of precision of a performance into its variability, by virtue of which the successive repetitions differ irregularly among themselves, and its constant error, by virtue of which all the repetitions differ in the same direction from the truly successful performance, then it appears that repetition will by itself reduce the variability, but will not eliminate the constant error, which can only be trained out by checking up the performance against the standard of success. Only repetition gives regularity; only correction conduces to perfection. When the standard of success is not very high, corrected practise leads to speedy perfection. When the operation is difficult or the standard of success high, as in telegraphy, the improvement, at first rapid, becomes discouragingly slow, but after several months of continued practise, may take a sudden rise, leading to a condition of passable proficiency, after which further gain is slower and slower, as the "physiological limit" of the individual for that performance is reached. But experiment has also shown that the physiological limit is seldom reached, or closely approached, in the usual, non-experimental conditions of the practise of a trade or profession. Type-setters, after ten to twenty years of experience, were thought by a certain investigator to be suitable subjects for an experiment in which it was desirable that the subjects should have reached their utmost efficiency. When the experiment was begun, an immediate rise was noted—which by itself was not surprising. What was surprising was that after this sudden jump, due to the increased stimulus of the test, there came a gradual rise, a practise curve, in fact, on top of ten to twenty years of practise. Similar results have appeared in other lines of work. Under the condition of a practise experiment, a German-English vocabulary can be learned with considerably greater speed—and

apparently also retained better—than in the ordinary conditions of school or private learning. The stimulating influence of the experimental conditions lies in part in the fact that the individual has a measure of his success, and in part in the competitive stimulus; he competes not only with others—a sort of competition which is usually unequal—but also with himself. Herein appears a contrast between introspective and dynamic studies: whereas the conditions of an introspective observation interfere to some degree with the process which is observed, an experiment in dynamic psychology is apt to arouse the function exercised to its full activity. The practical value of these results both to the educator and to any man in the conduct of his life and business is obvious. If one's work can be made an experiment, and the success of it measured and recorded, a great gain in efficiency may be expected.

Much of the newer and more exact work in one of the most flourishing departments of psychology, that which examines the mental capacities of various orders of animals, depends for its method on the study of the practise effect. The questions whether an animal can learn, how fast, how much, and by what means, are fundamental. Considerable revision in our conceptions has been brought about lately by the discovery that even protozoans can be taught, that their behavior is modifiable by experience. At the other end of the scale, tests show that the primates are nearest to man, not only in anatomy, but as well in fertility and quickness of learning, while still the highest forms which have so far been carefully studied are inferior to the human infant of the age of one year. The anthropoid apes have not as yet received the attention they deserve. The method has been employed in endeavoring to answer the vexed question regarding the reason of animals. Most of the discussion of this topic rested, till quite recently, on anecdotes rather than on experiment. The defect of the

anecdotal method is that, though the animal is known to have learned, no observations have been made as to how he learned. It may be asserted that no movement whatever, however skilled and however adaptive, can prove reason in its performer, in the absence of knowledge as to how the movement was acquired. The most wonderfully skilled and adaptive of all movements are inherited, not acquired, by the individual. The practise-curve method gives at least negative information in the following way: Whatever may be the full definition of reason, it is clear that in practical use it involves grasping the essential feature of the situation—essential, that is, for the purpose in hand—and reacting to this feature in neglect of the unessential. Place a human being in a cage from which he can escape by some concealed mechanism, and his first efforts will of necessity be blind experimenting, resulting finally in accidental success. Replace him in the cage, and in the course of a number of trials he will observe by what means his success comes, and will from that instant drop all his unsuccessful gropings and do only the one thing needful. No such moment of insight is revealed in the process by which a dog or cat learns most of his tricks, and in the case of the monkey, though the process of learning is rapid when the trick is simple enough, there is in more difficult cases no sign of a moment of comprehension. The difference may however be a matter of degree—of the degree of complexity which the different species are capable of grasping. When the thing to be learned is so simple as the mere location of an object that causes pain, it can be learned by a mouse in one or two trials. Harder tasks, such as pulling a string, which a cat learns only by a long and gradual process, are learned in a few trials by a monkey. A still more difficult performance, as, for example, the opening of a door by a combination of simple acts which must be done in a certain order, can hardly

if at all be taught to a cat, and to a monkey only by a slow process like that seen in the cat in learning the pulling of a string, while an adult man learns it in from two to six trials. But there are tasks yet more complicated and recondite, which even man learns only by the slow and gradual process—a process in which the essentials of success are never recognized, though success is finally attained by the gradual and unnoticed elimination of false moves. Examples of this process in man are seen in the acquisition of high skill in singing or playing the violin, or in handling the sword or tennis racquet. Insight is not entirely absent here, but insight alone does not do the work, as is seen from the fact that perfect form results only from the slow accretions of constant practise.

Besides animal psychology, the most cultivated among what may be called the outlying fields of psychology are the genetic and the pathological. Progress is being made in tracing the rate of growth of the capacities of the individual, in correlating mental with physical growth, and in assigning to hereditary endowment on the one hand and to experience and training on the other their contributions to the superiority or inferiority of the individual to his fellows—the preponderance certainly seeming to lie on the side of heredity. In mental pathology, a vast amount of preliminary prospecting has been done by physicians, and the ground prepared for more rigorous observation and experiment, which has indeed been begun, particularly with neurotic patients, hysterical neurasthenic and epileptic.

Abnormal psychology is in large measure an application of the science for the practical ends of diagnosis, of suggesting modes of treatment and of testing their success. It is hoped, not only that the results of psychology may help towards the understanding of mental abnormalities, but that the methods of psychology may prove capable of

adaptation to the needs of those who require quantitative tests of mental condition.

The principal application of psychology is, at present, to education. Such work as that above mentioned on practise and learning has an obvious bearing on the problems of the schoolroom, while some of the broader results of genetic psychology are germane to the task of those who arrange the courses of study. But, as with the applications to medicine, it is not simply the results of psychology that should prove fruitful in education; it is still more to be hoped that the empirical and experimental method may spread over from the one to the other. Education must become a science on its own account—an experimental science—related to psychology somewhat as engineering is related to physics, or agriculture to botany. With so much experience as he gets of the great differences in result that sometimes follow from slight changes in the conditions, the psychologist would be the first to admit that the conclusions reached in his laboratory ought not to be carried over without discrimination into the schoolroom. The problems of education must finally be solved by experimentation within the educational field.

With much the same reserve the psychologist approaches the possibility of applying his science to other fields, such as business—in which, for example, the conditions of successful advertising form clearly a psychological problem—and such as the practise of law. The courtroom teems with problems which are not simply psychological in the vague sense that they are concerned with mental processes, but are such as can be attacked by methods that have been worked out in psychology. The reliability of testimony, the influence of leading questions on the reliability of the answers, the relative merits of judge and jury as devices for establishing questions of fact, are fit subjects for an experiment, the main point of which

would be to insure that the facts regarding which the testimony is to be given be certainly known in advance to the experimenter. Some work has already been done by psychologists in collaboration with professors of law on the reliability of the testimony of eye-witnesses; and rather a surprising degree of unreliability has been disclosed. Not only is there a large percentage of omissions, but there is a smaller but still considerable percentage of positive assertions of what did not take place. It is almost impossible for anyone to witness an event without forming to himself some conception of its inner meaning and reading this meaning into the event as he sees and as he remembers it; and as a false meaning may very readily be read into events, the testimony will be correspondingly vitiated. Such general criticism as is implied in this result is perhaps of no great practical value; and in fact the legal profession has not received this incipient irruption of psychology into law with any great show of enthusiasm. But when the experiment is carried into details, and the varying reliability of testimony to different classes of facts and by different classes of persons is assigned—when, for example, it is found that the time occupied by an event is judged very poorly, that inherently probable and commonplace events are less reliably reported than inherently improbable, or that the reliability of a person's testimony bears no very close relation to the confidence with which he gives it—it would seem that the results were capable of application. Here again, however, the conclusions obtained in the laboratory need to be retested in the sphere where they are applied.

It is the hope of psychology that her results may prove capable of application in the work of her sister sciences, especially zoology, anthropology, sociology and every science that has to do with human or animal behavior. She comes in contact with still other sciences, especially with

physics, from which she derives much of her technical equipment; with mathematics, from which she derives the statistical methods that are necessary in much of her work; and even with astronomy, which gave the impetus to one of her earliest problems, that of reaction time and the personal equation. But it is to philosophy and physiology that the relations of psychology are particularly interesting. Psychology has sprung from each of them, though not exactly from their union. Both philosophy and medicine have been called mothers of the sciences, and psychology filially owns the relationship in each case. The philosophical parentage is of long standing, the medical or physiological—for in this instance it is fair to identify the two—dates from the last century. In spite of these historical dependences, psychology has the right to an independent standing as a science. The close relation of philosophical and psychological interests can easily be over-emphasized. Philosophy is not specially dependent on psychology; it needs the data of psychology, but it needs equally the data of the other sciences. Nor is the dependence of psychology on philosophy peculiarly close. Every science has its metaphysics, its presuppositions and ultimate questions the proof or solution of which is not approached by the methods appropriate to that science. The fact that students of psychology seem particularly prone to become worried over such questions is probably to be explained by the historical association of the two sciences, and is a tendency rather to be deprecated than encouraged. In the actual, immediate, concrete work of his science, the psychologist is no more concerned with metaphysical questions than is the chemist or the zoologist.

The relation of psychology to physiology is of a different kind. Physiology is not only occupied with applying physics and chemistry to the living organism—which is no doubt its main business—but also, finding certain organs

the function of which can not as yet be stated in physical and chemical terms, namely, the sense organs and the brain, and yet wishing, for the sake of completeness, to state the functions of these organs as well as may be, it has had recourse to methods which do not differ appreciably from those of psychology, depending as they do on the reactions and self-observation of the conscious subject. Thus the provinces of the two sciences overlap to quite an extent; and there are those who will have it that psychology, in so far as it amounts to anything, is but a part of physiology. The practical answer to this is that physiologists will not usually investigate such things as the peculiarities of memory and imagination. Were it not for the psychologist, the problems of mental action would remain unstudied. He comes in to fill the gap left by physiology because of the high development of its physical and chemical technique and the engrossing success which that technique is meeting.

But is this gap more than temporary? If the goal of the physiologist were attained, and all organic functions were dissected and accurately stated in physical and chemical terms, would there be anything left for the psychologist to say? Would not his cruder statements become obsolete, as the vague outlines of a landscape seen in the morning twilight lose their significance in the full, clear view of day?

Socrates, one of the founders of psychology, as he sat in prison with his disciples, waiting for the jailer to bring him the fatal draught of hemlock, alluded to the difference between the physiological and the psychological points of view in some such terms as these: "What should we think of a person who, when he endeavored to explain the causes of my actions, should proceed to explain that I sit here because my body is made up of bones and muscles: . . . and as the bones are lifted at their joints by the contrac-

tion or relaxation of the muscles, I am able to bend my limbs, and that is why I am sitting here in a curved posture; . . . and should give a similar explanation of my talking with you, which he would attribute to sound, and air, and hearing, and ten thousand other causes of the same sort; forgetting to mention the true cause, which is, that the Athenians have thought fit to condemn me, and accordingly I have thought it better and more right to remain here and undergo my sentence?"

The modern psychologist would not think so lightly of the physiological explanation; he recognizes in it one of the worthiest goals of scientific endeavor. But he would still maintain that the psychological interpretation of conduct has its proper place. The distinction is not properly that between mechanism and teleology; for a motive, to the psychologist, is a cause among causes. The difference is essentially one of minuteness; physiology being the more minute in its analysis of cause and effect. It is related to psychology much as microscopic is related to gross anatomy. Now the invention of the microscope has not made the sight of the naked eye valueless, even for scientific purposes. Microscopic anatomy has not supplanted gross anatomy but has simply been added to it. In much the same way, the conception of the geological ages is not made trivial by reflecting that the actual succession was one of seconds and not of ages. Detailed maps of every quadrangle in the country do not enable us to dispense with a condensed map of the whole country. The relations which are visible in the condensed map can not be grasped from the detailed maps. The relations brought out by geology would be lost sight of in following second by second, if that were possible, the physical and chemical history of the earth. In a word, the relations that appear in the gross disappear, give place to others, on a minuter view. A detailed view must always be a limited view, for no greater

assemblage of facts can be grasped in one act of comprehension when the facts are minute than when they are broad and inclusive. And as time and space are apparently divisible without limit, as to omniscience "a thousand years are as a day and a day as a thousand years," neither the broad nor the minute view can boast itself against the other. Examine every tissue of the body under the microscope, take cognizance of every cell, its form and relations; and you still know nothing of the facts taught by gross anatomy. Trace out each reaction of an animal, noting every transformation and transmission of energy from the point of stimulation to the point of response, and you still know nothing of animal behavior.

Quite akin to the science of behavior, psychology seeks to trace the relations of those rather gross fragments of the universal process which we call contents of consciousness and mental activities. Its dissection is less minute than that of physiology, but the relations which it reveals are none the less real, and may be none the less illuminating. Motives, conduct, training, efficiency, stages in the development and dissolution of the mind, will still retain their significance however minutely their inner mechanism shall be analyzed by physiology; and the relations between them which psychology discovers and is to discover will always retain both scientific and practical value.

METAPHYSICS

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
MARCH 18, 1908**



METAPHYSICS

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New York

THE COLUMBIA UNIVERSITY PRESS

1909

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Set up, and published April, 1908.

METAPHYSICS

THE first book to bear the title "Metaphysics" is attributed to Aristotle. If the title described or suggested the contents of the book, there might have been less confusion regarding the nature of the science. To some, however, it means the mysterious, to others, the exceptionally profound; while still others see in it an occasion for mirth. There have been, consequently, many definitions of metaphysics. The Century Dictionary gives, among others, the following: "The doctrine of first principles"; "Supernatural science; the doctrine of that which transcends all human experience"; "The science of the mind treated by means of introspection and analysis, and not by experiment and scientific observation"; "Any doctrine based upon presumption and not upon inductive reasoning and observation"; "An abstract and abstruse body of doctrine supposed to be virtually taken for granted in some science"; "Used frequently with the definite article, and generally connected with unpleasant associations, as being a study very dry and at the same time of doubtful truth." To these definitions might be added that by Professor James: "An unusually obstinate attempt to think clearly and consistently."

Such variety of definition is largely due to the fact that the title given to Aristotle's book was an unfortunate choice. It appears to indicate that when you have finished your physics, the science which was originally thought to embrace nature, you must then pass beyond physics and

somehow cut loose from nature herself. After physics, metaphysics; after nature, the supernatural—that is an invitation at once to titanic effort and to Icarian folly. Metaphysics came to suggest such human possibilities. Originally, however, the term represented no more than the happy thought of an enterprising editor. For, we are told, Andronicus of Rhodes, in the first century B. C., finding among the works of Aristotle a number of loosely connected writings which the great Greek had neglected to name, placed these writings after the books on physics, and named them accordingly, τὰ μετὰ τὰ φυσικά, the books which come after the books on physics. A name which thus indicated only an editorial arrangement became the name of a department of knowledge. That is not the only time when an editor's happy thought has been the cause of mischief.

If, however, we turn from the inspiring title to the writings themselves, illusions about the supernatural character of metaphysics tend to disappear. "There is," so we are told by the Stagirite, "a science which investigates existence as existence and whatever belongs to existence as such. It is identical with none of the sciences which are defined less generally. For none of these professedly considers existence as existence, but each, restricting itself to some aspect of it, investigates the general aspect only incidentally, as do the mathematical sciences." The emphasis is thus put by Aristotle on fact and on nature, but it is put on fact and nature as we attempt to view them with at once the least and with the greatest restriction: with the least restriction, because we are invited to view nature in the light of her most comprehensive characters; with the greatest restriction, because we are invited to view her stripped of her wonderful diversity.

In thus conceiving a science whose distinguishing mark should be that it applies to all existence, Aristotle noted a

fact which the history of intellectual progress has abundantly illustrated, the fact, namely, that knowledge grows in extent and richness only through specialization. Nature herself is a specialized matter. She does things by producing differences, individuals, variations. To grasp this variety, a variety of sciences is necessary. Indeed, as Aristotle estimates the achievements of his predecessors, he finds the source of their confusion, inadequacy, and limitation to lie in their habit of regarding each his own special science as a sufficient account of the cosmos. What they said may have been true under the restrictions which their limited field imposed upon their utterance; but it became false when it was transferred to other fields differently limited. Following his own illustrations we may say, for instance, that the Pythagoreans were quite right in trying to formulate the undoubted numerical relations which obtain in nature; but they were quite wrong if they conceived arithmetic to be an adequate astronomy. The soul may be a harmony of the body and thus capable of numerical expression, but to think one has exhausted its nature by defining it as a moving number is to forget the natural limitations of inquiry and to make a rhetorical phrase the substitute for scientific insight. We may properly speak of a sick soul as out of tune, but we should not thereby become either psychologists or physicians. No; knowledge is a matter of special sciences, each growing sanely as it clearly recognizes the particular and specialized aspect of nature with which it deals, but becoming confused when it forgets that it is one of many. Accordingly what we call the philosophy of Aristotle is not a single science to be described by a picturesque or a provoking name, but a system of sciences the members of which should be related to one another in the way nature rather than desire permits.

If knowledge increases thus through limitation, restriction, and specialization, if science grows through the mul-

tiplication of different sciences, must our final view of nature reveal her as a parceled and disjointed thing? Is the desire to say something about the universe as a whole which may none the less be true of it, is that desire without warrant, something utterly to be condemned? Not, thought Aristotle, if that desire is checked and controlled by fact. We should indeed err if we thought to attain unity through any artificial combination of special truths, or by attempting so to reduce the diversity of the sciences that their individual differences should disappear. Yet we may approach unity through the same method by which the special sciences gain their individual coherence and stability, that is, by limitation and restriction of field. All things somehow exist; and because they so obviously do, we can never lose sight of the fact that existence itself is a problem irrespective of the fact whether a particular existence is that of a stone, a man, or a god. Particular existences may carry us at last to some exclusive and inalienable core of individuality, hidden somewhere and possibly discoverable, but existence itself is possessed by nothing exclusively. It is rather the common feature of everything that can be investigated, and as such is something to be looked into. Whether such looking is fruitful is a question not to be prejudiced. The fruitfulness of the inquiry depends upon the discovery whether existence as such has anything to reveal. We thus return to Aristotle's conception of a science of existence as existence, a specialized and restricted science, doing its own work and not that of the mathematician or the physicist or the biologist, or of any other investigator, a science which should take its place in that system of sciences the aim of which is to reveal to us with growing clearness the world in which we live. It was that science which Andronicus of Rhodes called "Metaphysics," baptizing it in the name of ambiguity, confusion, and idiosyncrasy.

For me it would be a congenial task to devote the remainder of this lecture to a detailed exposition of the metaphysics of Aristotle. It would be the more congenial, since the lecturer on history, by making the ancients our contemporaries, has saved enthusiasm for the Stagirite from being condemned as a mere anachronism. To call Aristotle, as Dante is supposed to have done, the master of them that know, even if they know no less than others, is still a privilege in the twentieth century. And this privilege is the one *ad hominem* argument in justification of the study of metaphysics which I would venture to suggest to an audience already made somewhat familiar with the inadequacies and limitations of human knowledge. As the congenial, however, may not be the appropriate, I proceed to sketch the general bearings of metaphysics, pointing out how, beginning with analysis and description, it tends to become speculative, and to construct systems of metaphysics which aim at complete conceptions of the universe and have a certain relevancy to science, morals, and religion. Then I will indicate how metaphysics, influenced by modern idealistic speculation, became arrogant as a theory of knowledge, and how there are present signs of its return to its ancient place as a science coördinated with the rest of knowledge. In concluding, I will consider how, with this return, it finds a new interest in the interpretation of the process of evolution.

Either because Aristotle developed his science of existence with so much skill or because the science is to be reckoned, as he reckoned it, among those intellectual performances which are excellent, its unfortunate name has never completely obscured its professed aims and restrictions. Too often, indeed, metaphysics has been made the refuge of ignorance, and inquirers in other fields have been too ready to bestow upon it their own unsolved problems and inconsistencies. Many have thus been led to refuse

discussion of certain difficulties for the reason that they are metaphysical, a reason which may indicate that one is tired rather than that one is wise. It has even been suggested that so long as problems are unsolved they are metaphysical. Even so, the study, on account of the comprehensiveness thus given to it, might advance itself, imposing and commanding, a guarantor of intellectual modesty. Yet metaphysicians, as a rule, have not regarded their work as that of salvation. They have viewed their problems as the result of reflection rather than of emergency. And their reflection has ever seized upon the fact that nature's great and manifold diversities do, none the less, in spite of that diversity, consent to exist together in some sort of union, and that, consequently, some understanding of that unity is a thing to attempt. Metaphysics, therefore, may still adopt the definition and limitations set for it by Aristotle. We may, indeed, define it in other terms, calling it, for instance, the science of reality, but our altered words still point out that metaphysical interest is in the world as a world of connected things, a world with a general character in addition to those specific characters which give it its variety and make many sciences necessary for its comprehension.

The term "reality," however, is intellectually agile. It tends to play tricks with one's prejudices and to lead desire on a merry chase. For to denominate anything real is usually to import a distinction, and to consign, thereby, something else to the region of appearance. Could we keep the region of appearance from becoming populated, it might remain nothing more than the natural negative implication of a region of positive interest. But reality, once a king, makes many exiles who crave and seek citizenship in the land from which they have been banished. The term "reality," therefore, should inspire caution instead of confidence in metaphysics—a lesson which history has

abundantly illustrated, but which man is slow to learn. Contrast those imposing products of human fancy which we call materialism and idealism, each relegating the other to the region of appearance, and what are they at bottom but an exalted prejudice for matter and an exalted prejudice for mind? And had not their conflict been spectacular, as armies with banners, what a pitiable spectacle it would have presented, since a child's first thought destroys the one, and every smallest grain of sand the other? No; everything is somehow real; and to make distinctions within that realm demands caution and hesitation.

Thus it is that the concept of reality has become an important theme in a great part of metaphysical inquiry, and that a keen appreciation of its varieties is essential to the historian of metaphysics. That science has been thought to suffer from a too close scrutiny into the idiosyncrasies of its past; but being somewhat ancient and robust, and, withal, decidedly human, it may consult the reflection that more youthful sciences have not always walked in wisdom's path, and so bear its own exposure with some consequent consolation. Yet what it has to reveal in the light of the shifting concept of reality is significant indeed. For we have come to learn that to call anything real exclusively, is to imply a preference, and that preference is largely a matter of the time in which it is born. It reflects an age, an occasion, a society, a moral, intellectual, or economic condition. It does not reflect an absolute position which knows no wavering. For me, just now, metaphysics is the most real thing imaginable, more real than chemistry or the stock exchange. In displaying some enthusiasm for it, I care not if the elements revert to ether or how the market goes. To be invited just now to consider the periodic law or the latest market quotations, would irritate me. An altered situation would find me, doubtless, possessed of an altered preference, indifferent

no longer to another science or to the Street. So much does occasion determine preference, and preference reality.

The historical oppositions in metaphysics present themselves, therefore, not as a mass of conflicting and contradictory opinions about the absolutely real, but as a too exclusive championship of what their exponents have believed to be most important for their times. In such metaphysicians the enthusiasm of the prophet has outrun the disinterestedness of the scientist. We may describe them as men of restricted vision, but we may not, therefore, conclude that their vision was not acute. Plato was not an idle dreamer, assigning to unreality the bed on which you sleep in order that he might convince you that the only genuinely real bed is the archetype in the mind of God, the ideal bed of which all others are shadows. Undoubtedly he converses thus about beds in his "Republic," but he does not advise you, as a consequence, to go to sleep in heaven. He tells you, rather, that justice is a social matter which you can never adequately administer so long as your attention is fixed solely on individual concerns. You must seek to grasp justice as a principle, in the light of which the different parts of the body politic may find their most fruitful interplay and coördination. His metaphysics of the ideal was born of Athens' need, but his dialogues remain instructive reading for the modern man. We may confound him by pointing out the obvious fact that men, not principles, make society, and yet accept his teaching that men without principles make a bad society, exalting principles thus to the position of the eminently real.

Similarly, he who reads Fichte's "Science of Knowledge" should not forget that Fichte spoke to the German people, calling them a nation. And the response he met must have seemed, in his eyes, no small justification of his view that reality is essentially a self-imposed moral task. And Spencer, influenced by social and economic reorgani-

zation and consolidation, could force the universe into a formula and think that he had said the final word about reality. Thus any exclusive conception of reality is rendered great, not by its finality for all times, but by its historical appropriateness.

Such questions, therefore, as, What is real? Is there any reality at all? Is not everything illusion, or at least part of everything? and such statements as, Only the good is real, Only matter is real, Only mind is real, Only energy is real, are questions and statements to be asked and made only by persons with a mission. For reality means either everything whatsoever or that a distinction has been made, a distinction which indicates not a difference in the fact of existence, but a difference in point of view, in value, in preference, in relative importance for some desire or choice. Yet it is doubtless the business of metaphysics to undertake an examination and definition of the different points of view from which those questions can be asked and those statements made. Indeed, that undertaking may well be regarded as one of the most important in metaphysics. The outcome of it is not a superficial doctrine of the relativity of the real, with the accompanying advice that each of us select his own reality and act accordingly. Nor is it the doctrine that since nothing or everything is absolutely real, there is no solid basis for conduct and no abiding hope for man. That individualism which is willful and that kind of agnosticism which is not intellectual reserve, but which is intellectual complacency, have no warrant in metaphysics. On the contrary, the doctrine of metaphysics is much more obvious and much more sane. It is that existence, taken comprehensively, is an affair of distinctions; that existence is shot through and through with variety.

But this is not all. Metaphysics discovers in the fact of variety a reason for the world's onward movement. For

a world without variety would be a world eternally still, unchanged and unchanging through all the stretches of time. We might endow such a world with unlimited power, capable, if once aroused, of a marvelous reaction; but unless there existed somewhere within it a difference, no tremor of excitement would ever disturb its endless slumber. All the sciences teach this doctrine. Even logic and mathematics, the most static of them all, require variables, if their formulations are to have any significance or application. Knowledge thus reflects the basal structure of things. And in this fact that differences are fundamental in the constitution of our world, we discover the reason why all those systems of metaphysics eventually fail which attempt to reduce all existence to a single type of reality devoid of variety in its internal make-up.

The variety in our world involves a further doctrine. While all varieties as such are equally real, they are not all equally effective. They make different sorts of differences, and introduce, thereby, intensive and qualitative distinctions. The onward movement of the world is thus, not simply successive change, but a genuine development or evolution. It creates a past the contents of which must forever remain what they were, but it proposes a future where variety may still exercise its difference-making function. And that is why we human beings, acting our part in some cosmic comedy or tragedy, may not be indifferent to our performance or to the preferences we exalt. The future makes us all reformers, inviting us to meddle with the world, to use it and change it for our ends. The invitation is genuine and made in good faith, for all man's folly is not yet sufficient to prove it insincere. That is why it has been easy to believe that God once said to man: "Be fruitful and multiply, and replenish the earth, and subdue it; and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth

upon the earth." That is why, also, willful individualism and complacent agnosticism have no warrant in metaphysics. Since all things are equally real, but all not equally important, the world's evolution presents itself as a drift towards results, as something purposeful and intended. While we may not invoke design to explain this relative importance of things, the world's trend puts us under the natural obligation of discovering how it may be controlled, and enforces the obligation with obvious penalties. Thus willfulness receives natural punishment and the universe never accepts ignorance as an excuse.

It seems difficult, therefore, not to describe evolution as a moral process. By that I do not mean that nature is especially careful about the kinds of things she does or that she is true and just in all her dealings. But evolution is movement controlled by the relative importance of things. We consequently find such terms as "struggle," "survival," "adaptation," useful in the description of it. And although these terms may appear more appropriate to the development of living things than to that of inorganic nature, we may not overlook the fact that the physical world also begets varieties and has its character determined by their relative importance.

Thus it is that the metaphysical doctrine of final causes appears to be fundamentally sound. It is easy to render it ridiculous by supposing that things were once made on purpose to exhibit the features and manners of action which we now discover in them, or by conceiving adaptation as an efficient cause of events, as if the fact that we see were the reason why we have eyes. So conceived the doctrine of final causes is justly condemned. On the other hand, however, how superficial is the opinion that in nature there is entire indifference to results, and that there are no natural goods! To-day is not simply yesterday rearranged or twenty-four hours added to a capricious time; it is

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yesterday reorganized, with yesterday's results carried on and intensified. So that we might say that nature, having accidentally discovered that the distinction between light and darkness is a natural good, stuck to the business of making eyes. We should thus express a natural truth, but should not thereby free ourselves from the obligation of discovering how nature had achieved so noteworthy a result. That obligation the doctrine of final causes most evidently does not discharge, because final causes have never been found adequate to reveal the method of nature's working. Again and again, some investigator, impressed by the undoubted fact of nature's continuity, by her carefulness of the type, by her preservation of forms, by that character of hers which we can properly describe only by calling it preferential or moral, impressed by these things he has attempted to turn them into efficient causes, factors operative in the mechanism of the world. And he has repeatedly failed. It is, consequently, not prejudice which leads many students of nature's processes to insist that these are ultimately what we call mechanical. It is metaphysical insight. Yet that insight may readily degenerate into the most superficial philosophy, if it leads us to forget that mechanism is the means by which the ends of nature are reached. For nature undoubtedly exists for what she accomplishes, and it is that fact which gives to mechanism its relevancy, its importance, and its high value. Thus metaphysics, true to its early formulations, finds the world to be both mechanical and teleological, both a quantitative relation of
parts and a qualitative realization of goods. Some indication that this finding is correct may be discovered in our instinctive recognition that nature is appropriately described both in the formulations of science and in the expressions of poetry.

Metaphysical analysis tends thus to disclose existence as

a process motived by the variety of its factors, as an evolution characterized, not by indifference, but by selection based on the relative importance of its factors for the maintenance of natural goods, as a development executed through an elaborate mechanism. It is natural that metaphysics should become speculative and attempt the construction of a system of things wherein its obvious disclosures may be envisaged with coherence and simplicity, and thus be rationally comprehended and explained. It is in such attempts that metaphysics has historically scored its greatest successes and its greatest failures. The lesson to be derived from a survey of them is, doubtless, one of grave caution, but it would be idle to affirm that we have seen the last of great systems of metaphysics. Democritus, Plato, Aristotle, Bruno, Descartes, Hobbes, Spinoza, Newton, Leibnitz, Berkeley, Kant, Laplace, Hegel, Spencer—to mention only the greatest names—each has had his system of the world which still has power to affect the thought and lives of men. System is beloved of man's imagination and his mind is restless in the presence of unconnected and unsupported details. He will see things *sub specie æternitatis* even while time counts out his sands of life. It is a habit begotten of nature, to be neither justified nor condemned. It would be absurd, consequently, to regard any system of metaphysics as absolutely true, but it would be more absurd to refuse to make one on that account. For such systems constitute the supreme attempts of intelligence at integration. They propose to tell us what our world would be like if our present restricted knowledge were adequate for its complete exposition. They are not, therefore, to be abandoned because they are always inadequate, incomplete, and provisional; they are rather to be pursued, because, when constructed by the wise, they are always ennobling and minister faithfully to the freedom of the mind.

Protests against metaphysical systems are, consequently, apt to be proofs of an impatient temper rather than of sound judgment. Yet such systems often grow arrogant, and become, thereby, objects of justified suspicion. Being the crowning enterprise of intelligence, to be worn, one might say, as an indication of a certain nobility of mind, they forfeit the claim to be thus highly regarded if they are made the essential preliminaries of wisdom. Yet the too eager and the too stupid have often claimed that the only possible foundation for the truth and value of science, and the only possible warrant for morality and human aspiration, are to be found in a system of metaphysics. If such a claim meant only that with a perfect system, could we attain it, would riddles all be solved and life's darkness made supremely clear, it would express an obvious truth. But made with the intent of laying metaphysics down as the foundation of science, of morality, and of religion, it is obviously false and iniquitous. In our enthusiasm we may indeed speak of metaphysics as the queen of all the sciences, but she can wear the title only if her behavior is queenly; she forfeits it when, ceasing to reign, she stoops to rule.

Yet there is justice in the notion that metaphysics, especially in its systematic shape, should contribute to the value of science, and be a source of moral and religious enlightenment. Its greatest ally is logic. In the systematic attempt to reduce to order the business of getting and evaluating knowledge, in distinguishing fruitful from fruitless methods, and, above all, in attempting to disclose the sort of conquest knowledge makes over the world, the aims and achievements of science should become better appreciated and understood. It is still true, as Heraclitus of old remarked, that much information does not make a man wise, but wisdom is intelligent understanding.

The disclosures of metaphysics are equally significant

for ethics. The great systems have usually eventuated in a theory of morals. And this is natural. Metaphysics, disclosing the fact that behavior is a primary feature of things, raises inevitably the question of how to behave effectively and well. Emphasizing the relative importance of the factors of evolution, it encourages the repeated valuation of human goods. It can make no man moral, nor give him a rule to guide him infallibly in his choices and acts; but it can impress upon him the fact that he is under a supreme obligation, that of living a life controlled, not by passion, but by reason, and of making his knowledge contribute to the well-being of society. It will still preach its ancient moral lesson, that since with intelligence has arisen some comprehension of the world, the world is best improved, not by passions or by parties, not by governments or by sects, but by the persistent operation of intelligence itself. ✓

After a somewhat similar manner, metaphysics in its systematic character has significance for theology. To speak of existence as a riddle is natural, because so much of its import can be only guessed. That it has import, most men suspect, and that this import is due to superior beings or powers is the conviction of those who are religious. Metaphysics is seldom indifferent to such suspicions and convictions. As it has a lively sense of the unity of things, it is led to seek ultimate reasons for the world's stability. And as it deals with such conceptions as "the infinite" and "the absolute," it has a certain linguistic sympathy with faith. Consequently, while it has never made a religion, it has been used as an apology for many. This fact witnesses, no doubt, more profoundly to the adaptability of metaphysics than it does to the finality of the ideas it has been used to sustain. Yet metaphysics, tending to keep men ever close to the sources of life, fosters a whole-hearted acceptance of life's responsibilities and +

duties. It is thus the friend of natural piety. And in superimposing upon piety systematic reflection on what we call the divine, it follows a natural instinct, and seeks to round out man's conception of the universe as the source of his being, the place of his sojourning, the begetter of his impulses and his hopes, and the final treasury of what he has been and accomplished.

Such, then, are the general nature and scope of metaphysical inquiry. With Aristotle we may define metaphysics as the science of existence and distinguish it from other departments of knowledge by its generality and its lack of attention to those specific features of existence which make many sciences an intellectual necessity. Existence, considered generally, presents itself as an affair of connected varieties and, consequently, as an onward movement. Because the varieties have not all the same efficacy, the movement presents those selective and moral characters which we ascribe to a development or evolution. While the efficient causes of this evolution appear to be mechanical, the mechanism results in the production of natural goods, and thus justifies a doctrine of final causes. Upon such considerations metaphysics may superimpose speculative reflection, and attempt to attain a unified system of the world. It may also attempt to evaluate science in terms of logical theory, to enlarge morality through a theory of ethics, and to interpret natural piety and religion in terms of theological conceptions. Metaphysics proposes thus both an analysis and a theory of existence; it is descriptive and it is systematic. If metaphysicians often forget that theory is not analysis, that system is not description, it is not because they are metaphysicians, but because they are human. For my part, therefore, I do not see why they should not be allowed to entertain at least as many absurdities as the average reflective inquirer. Greater indulgence is neither desired nor necessary. And while meta-

physicians may be hard to understand, they do not like to be misunderstood. So I emphasize again the fact that it appears to be the greatest abuse of metaphysical theories to use them to justify natural excellence or to condone natural folly. It is their business to help to clarify existence. It is not their business to constitute an apology for our prejudices or for our desires.

In regarding metaphysics as the outcome of reflection on existence in general, and, consequently, as a department of natural knowledge, I have supposed that intelligent persons could undertake such reflection and accomplish something of interest and consequence, by following the ordinary experimental methods of observation and tested generalization. I have stated that the contrast between metaphysics and other departments of knowledge arises from its emphasis on generalities and their emphasis on particulars. In doing all this I have followed ancient tradition. But much of modern philosophy has emphatically declared that such an attitude is decidedly too naïve. Keenly alive to the fact, which it credits itself with discovering, the fact, namely, that the world into which we inquire exists for us only as the mind's object, that philosophy has insisted that the mind is central in the universe, and that the nature and laws of mind are, therefore, the determining factors in the structure of the world we know.

Of this view Kant was the great systematic expounder. It was he who taught that space and time are but the forms of sense perception. It was he who declared that the basal principles of physics are but derivatives of the principles of the mind. It was he who affirmed that by virtue of our understanding we do not discover the laws of nature, but impose them. He consequently drew the conclusion that we know only the appearances of things connected according to the laws of the mind, but never the things them-

selves connected according to their own laws. The moral he drew pointed in the direction of intellectual modesty and an enlightened reliance on experience. But to make nature nothing but a collection of appearances in the mind, united according to the supposed necessities of thought, is really to discourage experience and bid imagination riot. For in the critical philosophy of Kant we have suggested a science which is higher than the sciences, a set of principles upon which they depend, and from which might possibly be deduced by the mere operation of thought all that is essential to their content. We have also suggested a method of inquiry which is no longer based on experimental observation and generalization, but which is controlled by principles supposed to be purely *a priori*, and thus more fundamental than experience itself. Metaphysics, by entering that supposed region of purer insight, cut itself off from all helpful competition and coördination with the rest of knowledge. It begot those great systems of idealistic philosophy which Professor Santayana has characterized as "visionary insolence." It produced that lamentable conflict between science and metaphysics which was so characteristic of the last century. No department of knowledge can thrive in isolation. If metaphysics, by arrogating to itself supremacy, tended to become visionary, the sciences also, despising metaphysical insight, tended to become disorganized and illiberal.

Happily in our own day there are many signs that this unfortunate antithesis between science and metaphysics is disappearing. Metaphysics itself, by a sort of inner evolution, has been working out to a more objective view of things. On the other hand, the sciences, through their own extension, have come upon unsuspected generalities and coördinations. Above all, the principle of evolution, which was early recognized in metaphysical theories, has served, by its general recognition in all departments of

knowledge, to restore unity among the sciences. It has forced idealism to recognize that even intelligence, the mind itself, has had a natural history. Metaphysics is thus leaving its position of isolation, and returning to its ancient place as a science coördinated with the rest of knowledge.

But it returns not without modification and not without its own interest in evolutionary theory. It will still, as of old, seek to discover the basal types of existence and their general modes of operation. It will still ask, What can we say of existence as a whole which is true of it? But it has learned from idealism that while it may view intelligence as the instrument of knowledge, it may not hope to understand nature as a process if the place of intelligence in that process is disregarded. For to reconstruct in thought the world's vanished past and to forecast its possible future is to give to intelligence a certain baffling and perplexing importance in the scheme of things. In attacking this problem of the place of intelligence in an evolving world, metaphysics may not, however, boast that it has a method peculiarly its own. It may not hope to control the inquiry by principles supposed to be derived from pure reason and thus to have a higher warrant than the principles employed in other sciences. For metaphysics has come to believe in the evolution of intelligence because it has been so taught by the method of experimental investigation. It can not, therefore, discredit that method without discrediting its own belief.

We may, indeed, be at first bewildered by the fact that the world in which intelligence has evolved is the world which intelligence has discovered; but if we accept the discovery, we do but recognize in intelligence a natural good whose use and final cause is to make us somewhat acquainted with our dwelling-place. The world thus exists as just what we have discovered it to be, the place in which

intelligence has dawned and led to a knowledge of the process in which such a great event has happened. It is natural, therefore, to claim that in reflecting on our world we may largely disregard the fact that we reflect. Realizing that in him has arisen intelligence, knowledge, understanding of the world, as the stoutest weapon in his life's warfare, man realizes that his weapon is for use rather than for scrutiny. Its excellence is to be tested by the territory won, and not by inquisitive feeling of the sharpness of the blade—especially when that blade sharpens only with its conquering use. Thus, as I say, we may largely disregard the fact that we reflect. By so doing, the world grows to clearness as the thing reflected on. Its laws and processes take shape in useful formulas. It is thus that the sciences advance to their great contributions. And why not, then, metaphysics? Why should we rather hope that by making the mind itself exclusively the object of our study, an added clearness will be given to the scheme of things?

But we can never wholly disregard the fact that we reflect, because the dawn of intelligence in the world is an event of too great interest to be accepted merely as a matter of record. If we are warranted in regarding it as a natural good whose use is to acquaint us with the world, we are, doubtless, also warranted in regarding it as the situation in which the world's evolution is most clearly and effectively revealed. If, now, we interpret this situation as differing from all others only by the fact that in it we have immediate knowledge of what it is to be an evolution, we attain a suggestive basis for generalization. From it we find little warrant to conclude that the present is simply the unfolding of a past, possibly of a very remote past, or that the future is simply the present unfolded. Evolution appears to be a process of a totally different sort. It appears to be always and eternally the unfolding of an effective present. Behind it, it leaves the past as the record

of what it has done, the totality of things accomplished, but not the promise and potency of things to be. It is a dead past. As such it may be conditioning; but it is not effective, because it is accomplished. To the present alone belong the riches of potentiality and spontaneity; to it alone belongs efficiency. We are, thus, under no obligation to seek in endless regress through the past the source of the world's becoming or the secret of its variety and human interest.

If such an interpretation of evolution is warranted, that process may indeed be described as having purpose. Only we may not understand by purpose some anciently conceived plan which the world was intended to follow. We should not invoke foresight, but should recognize historical continuity. For when we have a process going on in such a manner that the present of it is continually transforming itself into the record of what it has done, writing, as it were, a cosmic history, then, surely, we have a purpose. Such a process can be comprehended only as one having meaning and significance. Its factors are bound together not only as cause and effect, but also as means and end. Shed intelligence upon any of its events, and the question, Why? will leap into being with its insistent demands. The question sends us searching through the records of the past and the promise of the future in order that the event may be estimated at its proper value. Only by such searching may we hope to discover what the world's purpose is. We may call it, in one word, achievement. And I must believe, just because achievement is wrought through an effective present, that the world, as it passes from moment to moment of its existence, carries ever with it perennial sources of outlook and novelty. And I must believe, too, that just in proportion as we free ourselves from the desperate notion that somewhere and somehow hope and outlook have been, once for all, fixed unalterably for the

world's future, we shall then find in our union with nature a source of genuine enthusiasm.

Yes, we can not wholly disregard the fact that we reflect. We must note that the knowledge of the evolution of intelligence is itself a product of intelligence. Thus taking note, we may discover in the evolution of intelligence, not only the world grown to the highest point of varied and efficient action that we know, but evolution itself disclosed for what it is in its essential nature. It is the ceaseless unfolding of an effective present which carries with it the sources of what it achieves, and whose achievements have the value they disclose as discovered factors in the universal history of the world.

ETHICS

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
MARCH 25, 1908**



ETHICS

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New York

THE COLUMBIA UNIVERSITY PRESS

1909

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Set up, and published May, 1908.

ETHICS

"EXCEPT the blind forces of nature," said Sir Henry Maine, "nothing moves in this world which is not Greek in its origin." And if we ask why this is so, the response comes that the Greek discovered the business of man to be pursuit of good, and intelligence to be central in this quest. The utmost to be said in praise of Plato and Aristotle is not that they invented excellent moral theories, but that they rose to the opportunity which the spectacle of Greek life afforded. For Athens presented an all but complete microcosm for the study of the interaction of social organization and individual character. A public life of rich diversity in concentrated and intense splendor trained the civic sense. Strife of faction and the rapid oscillations of types of polity provided the occasion for intellectual inquiry and analysis. The careers of dramatic personalities, habits of discussion, ease of legislative change, facilities for personal ambitions, distraction by personal rivalries, fixed attention upon the elements of character; and upon the valuation of the functions of individuals with respect to their effect upon social vitality and stability. Happy exemption from ecclesiastic preoccupations, susceptibility to natural harmony, and natural piety conspired with frank and open observation to acknowledgment of the rôle played by natural conditions. Social instability and shock made equally pertinent and obvious the remark that only intelligence can confirm the values which

natural conditions generate, and that intelligence is itself nurtured and matured only in a free and stable society.

In Plato the resultant keen analysis of the mutual implications of the individual, the social and the natural, converged in the ideas that morals and philosophy are one:—the love of that wisdom which is the source of secure and social good; that mathematics and the natural sciences focussed upon the problem of the adequate perception of the good furnish the methods of moral science; that logic is the vital method of the pregnant organization of social materials with respect to good; that politics and psychology are sciences of one and the same human nature, taken first in the large and then in the little. So far that large and expansive vision of Plato.

But projection of a better life must be based upon reflection of the life already lived. The inevitable limitations of the Greek city-state were as inevitably wrought into the texture of moral theory.

The business of thought was to furnish a substitute for customs, which were then relaxing from the pressure of contact and intercourse without, and disintegrating from strife within. Reason was to take the place of custom as a guide of life; but it was to furnish rules as final, as unalterable as those of custom. In short, the thinkers were themselves fascinated by the afterglow of custom. They took for their own ideal the distillation from custom of its essence—ends and laws which should be rigid and invariable. Thus Morals was set upon the track which it dared not leave for nigh twenty-five hundred years: search for *the* final good, and for *the* single moral force.

Aristotle's assertion that the state exists by nature, and that in the state alone does the individual achieve independence and completeness of life, are indeed pregnant sayings. But as uttered by Aristotle they meant that, in an isolated state, the Greek city-state, set a garlanded island in

the waste sea of *barbaroi*, a community indifferent when not hostile to all other social groupings, individuals attain their full end. In a social unity which signified social contraction, contempt and antagonism, in a social order which despised intercourse and glorified war, is realized the life of excellence!

There is likewise a profound saying of Aristotle's that the individual who otherwise than by accident is not a member of a state is either a brute or a god. But it is generally forgotten that elsewhere Aristotle identified the highest excellence, the chief virtue, with pure thought, and identifying this with the divine, isolated it in lonely grandeur from the life of society. That man, so far as in him lay, should be godlike, meant that he should be non-social, because supra-civic. Plato the idealist had shared the belief that reason is the divine; but he was also a reformer and a radical and he would have those who attained rational insight descend again into the civic cave, and in its obscurity labor patiently for the enlightenment of its blar-eyed inhabitants. Aristotle, the conservative and the definer of what is, gloried in the exaltation of intelligence in man above civic excellence and social need; and thereby isolated the life of truest knowledge from contact with social experience and from responsibility for discrimination of values in the course of life.

Moral theory however accepted from social custom more than its cataleptic rigidity, its exclusive area of common good and its unfructified and irresponsible reason. The city-state was a superficial layer of cultured citizens, cultured through a participation in affairs made possible by relief from economic pursuits, superimposed upon the dense mass of serfs, artisans and laborers. For this division, moral philosophy made itself spiritual sponsor, and thus took it up into its own being. Plato wrestled valiantly with the class problem; but his outcome

was the necessity of decisive demarcation, after education, of the masses in whom reason was asleep and appetite much awake, from the few who were fit to rule because alertly wise. The most generously imaginative soul of all philosophy could not far outrun the institutional practices of his people and his times. This might have warned his successors of the danger of deserting the sober path of a critical discernment of the better and the worse within contemporary life for the more exciting adventure of a final determination of absolute good and evil. It might have taught the probability that some brute residuum or unrationalized social habit would be erected into an apotheosis of pure reason. But the lesson was not learned. Aristotle promptly yielded to the besetting sin of all philosophers, the idealization of the existent: he declared that the class distinctions of superiority and inferiority as between man and woman, master and slave, liberal-minded and base mechanic, exist and are justified by nature—a nature which is embodied reason.

What, finally, is this Nature to which the philosophy of society and the individual so bound itself? It is the nature which figures in Greek custom and myth; the nature resplendent and adorned which confronts us in Greek poetry and art: the animism of savage man purged of grossness and generalized by unerring æsthetic taste into beauty and system. The myths had told of the loves and hates, the caprices and desertions of the gods, and, behind them all, inevitable fate. Philosophy translated these tales into formulæ of the brute fluctuation of rapacious change held in bounds by the final and supreme end: the rational good. The animism of the popular mind died to reappear as cosmology.

Repeatedly in this course we have heard of sciences which began as parts of philosophy and which gradually won their independence. Another statement of

the same history is that both science and philosophy began in subjection to mythological animism. Both began with acceptance of a nature whose irregularities displayed the meaningless variability of foolish wants held within the limits of order and uniformity by an underlying movement toward a final and stable purpose. And when the sciences gradually assumed the task of reducing irregular caprice to regular conjunction, philosophy bravely took upon itself the task of substantiating, under the caption of a spiritual view of the universe, the animistic survival. Doubtless Socrates brought philosophy to earth; but his injunction to man to know himself was incredibly compromised in its execution by the fact that later philosophers submerged man in the world to which philosophy was brought: a world which was the heavy and sunken centre of hierarchic heavens located in their purity and refinement as remote as possible from the gross and muddy vesture of earth.

The various limitations of Greek custom, its hostile indifference to all outside the narrow city-state, its assumption of fixed divisions of wise and blind among men, its inability socially to utilize science, its subordination of human intention to cosmic aim—all of these things were worked into moral theory. Philosophy had no active hand in producing the condition of barbarian in Europe from the fifth to the fifteenth centuries. By an unwitting irony which would have shocked no one so much as the lucid moralists of Athens, their philosophic idealization, under captions of Nature and Reason, of the inherent limitations of Athenian society and Greek science, furnished the intellectual tools for defining, standardizing and justifying all the fundamental clefts and antagonisms of feudalism. When practical conditions are not frozen in men's imagination into crystalline truths, they are naturally fluid. They come and go. But when in-

telligence fixes fluctuating circumstance into final ideals, petrification is likely to occur; and philosophy gratuitously took upon itself the responsibility for justifying the worst defects of barbarian Europe by showing their necessary connexion with divine reason.

The division of mankind into the two camps of the re-deemed and the condemned had not needed philosophy to produce it. But the Greek cleavage of men into separate kinds on the basis of their position within or without the city-state was used to rationalize this harsh intolerance. The hierarchic organization of feudalism, within church and state, of those possessed of sacred rule and those whose sole excellence was obedience, did not require moral theory to generate or explain it. But it took philosophy to furnish the intellectual tools by which such chance episodes were emblazoned upon the cosmic heavens as a grandiose spiritual achievement. No; it is all too easy to explain bitter intolerance and desire for domination. Stubborn as they are, it was only when Greek moral theory had put underneath them the distinction between the irrational and the rational, the divine truth and good and the corrupt and weak human appetite, that intolerance on system and earthly domination for the sake of eternal excellence became philosophically sanctioned. The health and welfare of the body and the securing for all of a certain and a prosperous livelihood were not matters which medieval conditions much fostered in any case. But moral philosophy was prevailed upon to damn the body on principle, and to relegate to insignificance as merely mundane and temporal the problem of a just industrial order. Circumstances of the times bore with sufficient hardness upon successful scientific investigation; but philosophy added the conviction that in any case truth is so supernal that it must be supernaturally revealed, and so important that it must be authoritatively imparted and enforced. Intelligence was diverted from the

critical consideration of differences of better and worse in their natural sources and social consequences, into the channel of metaphysical subtleties and systems, acceptance of which was made essential to participation in the social order and in rational excellence. Philosophy it was which bound the erect form of human endeavor and progress to the chariot wheels of cosmology and theology.

Since the Renaissance, moral philosophy has repeatedly reverted to the Greek ideal of natural excellence realized in social life, under the fostering care of intelligence in action. The return, however, has taken place under the influence of democratic polity, commercial expansion and scientific reorganization. It has been a liberation even more than a reversion. This combined return and emancipation, having transformed our practice of life in the last four centuries, will not be content till it has written itself clear in our theory of that practice. Whether the consequent revolution in moral philosophy be termed pragmatism or be given the happier title of the applied and experimental habit of mind is of little account. What is of moment is that intelligence has descended from its lonely isolation at the remote edge of things, whence it operated as unmoved mover and ultimate good, in order to take its seat in the moving affairs of men. Theory may therefore become responsible to the practices which have generated it; the good be connected with nature, but with nature naturally, not metaphysically, conceived, and social life be cherished in behalf of its own immediate possibilities, not on the ground of its remote connexions with a cosmic reason and an absolute end.

There is an idea, more familiar than correct, that Greek thought sacrificed the individual to the state. None has ever known better than the Greek that the individual comes to himself and to his own, only in association with others. But Greek thought subjected, as we have seen, both state and

individual to an external cosmic order; and thereby it inevitably restricted the free use, in doubt, inquiry and experimentation, of the human intelligence. The *anima libera*, the free mind of the sixteenth century, of Galileo and his successors, was the counterpart of the disintegration of cosmology and its animistic teleology. The lecturer on political economy reminded us that his subject began, in the middle ages, as a branch of ethics, though, as he hastened to show, it soon got into better associations. Well, the same company was once kept by all the sciences, mathematical and physical as well as social. According to all accounts it was the integrity of the number one and the rectitude of the square that attracted the attention of Pythagoras to arithmetic and geometry as promising fields of study. Astronomy was the projected picture book of a cosmic object lesson in morals, Dante's transcript of which is none the less literal because poetic. If physics alone remained outside the moral fold, while noble essences redeemed chemistry and occult forces blessed physiology, and the immaterial soul claimed psychology, physics is the exception that proves the rule: matter was so inherently immoral that no high-minded science would demean itself by contact with it.

If we do not join with many others in lamenting the stripping off from nature of those idealistic properties in which animism survived, if we do not mourn the secession of the sciences from ethics, it is because the abandonment by intelligence of a fixed and static moral end was the necessary precondition of a free and progressive science; because the emancipation of the sciences from ready made, remote and abstract values was necessary to make the sciences available for creating and maintaining more and better values here and now. The divine comedy of modern medicine and hygiene is one of the human epics yet to be written; but when composed it may prove no unworthy companion of the medieval epic of other worldly beatific visions. The

great ideas of the eighteenth century, that expansive epoch of moral perception which ranks in illumination and fervor along with classic Greek thought, the great ideas of the indefinitely continuous progress of humanity and of the power and significance of freed intelligence, were borne by a common mother—the development of experimental inquiry.

The growth of industry and commerce is at once cause and effect of the growth in science. Democritus and other ancients conceived the mechanical theory of the universe. The notion was not only blank and repellent, because it ignored the rich social material which Plato and Aristotle had organized into their rival idealistic views; but it was scientifically sterile, a piece of dialectics. Contempt for machines as the accoutrements of despised mechanics kept the mechanical conception aloof from these specific and controllable experiences which alone could fructify it. This conception, then, like the idealistic, was translated into a speculative cosmology and thrown like a vast net around the universe at large, as if to keep it from coming to pieces. It is from respect for the lever, the pulley and the screw that modern experimental and mathematical mechanics derives itself. Motion, traced through the workings of a machine, was followed out into natural events and studied just as motion, not as a poor yet necessary device for realizing final causes. So studied, it was found to be available for new machines and new applications, which in creating new ends also promoted new wants, and thereby stimulated new activities, new discoveries and new inventions. The recognition that natural energy can be systematically applied, through experimental observation, to the satisfaction and multiplication of concrete wants is doubtless the greatest single discovery ever imported into the life of man—save perhaps the discovery of language. Science, borrowing from industry, repaid the debt with interest, and has

made the control of natural forces for the aims of life so inevitable, that for the first time man is relieved from overhanging fear, with its wolflike scramble to possess and accumulate, and is freed to consider the more gracious question of securing to all an ample and liberal life. The industrial life had been condemned by Greek exaltation of abstract thought and by Greek contempt for labor as representing the brute struggle of carnal appetite for its own satiety. The industrial movement, offspring of science, restored it to its central position in morals. When Adam Smith made economic activity the moving spring of man's unrelenting effort, from the cradle to the grave, to better his own lot, he recorded this change. And when he made sympathy the central spring in man's conscious moral endeavor, he reported the effect which the increasing intercourse of men, due primarily to commerce, had in breaking down suspicion and jealousy and in liberating man's kinder impulses.

Democracy, the crucial expression of modern life, is not so much an addition to the scientific and industrial tendencies as it is the perception of their social or spiritual meaning. Democracy is an absurdity where faith in the individual as individual is impossible; and this faith is impossible when intelligence is regarded as a cosmic power, not an adjustment and application of individual tendencies. It is impossible when appetites and desires are conceived to be the dominant factor in the constitution of most men's characters, and when appetite and desire are conceived to be manifestations of the disorderly and unruly principle of nature. To put the intellectual centre of gravity in the objective cosmos, outside of men's own experiments and tests, and then to invite the application of individual intelligence to the determination of society is to invite chaos. To hold that want is mere negative flux and hence requires external fixation by reason, and then to invite the wants to

give free play to themselves in social construction and intercourse is to call down anarchy. Democracy was conceivable only with a changed conception of the intelligence that forms modern science and the want that forms modern industry. It is essentially a changed psychology. The substitution, for a *priori* truth and deduction, of fluent doubt and inquiry, meant trust in human nature in the concrete; in individual honesty, curiosity and sympathy. The substitution of moving commerce for fixed custom meant a view of wants as the dynamics of social progress, not as the pathology of private greed. The nineteenth century indeed turned sour on that somewhat complacent optimism in which the eighteenth century rested: the ideas that the intelligent self-love of individuals would conduce to social cohesion, and competition among individuals usher in the kingdom of social welfare. But the conception of a social harmony of interests in which the achievement by each individual of his own freedom should contribute to a like perfecting of the powers of all, through a fraternally organized society, is the permanent contribution of the industrial movement to morals—even though so far it be but the contribution of a problem.

Intellectually speaking, the centuries since the fourteenth are the true middle ages. They mark the transitional period of mental habit, as the so-called medieval period represents the petrification, under changed outward conditions, of Greek ideas. The conscious articulation of genuinely modern tendencies has yet to come, and till it comes the ethic of our own life must remain undescribed. But the system of morals which has come nearest to the reflection of the movements of science, democracy and commerce, is doubtless the utilitarian. Scientific, after the modern mode, it certainly would be. Newton's influence dyes deep the moral thought of the eighteenth century. The arrangements of the solar system had been described in terms of a homogeneous matter and motion, worked by two opposed and com-

pensating forces: all because a method of analysis, of generalization by analogy, and of mathematical deduction back to new empirical details had been followed. The imagination of the eighteenth century was a Newtonian imagination; and this no less in social than in physical matters. Hume proclaims that morals is about to become an experimental science. Just as, almost in our own day, Mill's interest in a method for social science led him to reformulate the logic of experimental inquiry, so all the great men of the Enlightenment were in search for the organon of morals which should repeat the physical triumphs of Newton. Bentham notes that physics has had its Bacon and Newton; that morals has had its Bacon in Helvétius, but still awaits its Newton; and he leaves us in no doubt that at the moment of writing he was ready, modestly but firmly, to fill the waiting niche with its missing figure.

The industrial movement furnished the concrete imagery for this ethical renovation. The utilitarians borrowed from Adam Smith the notion that through industrial exchange in a free society the individual pursuing his own good is led, under the guidance of the "invisible hand," to promote the general good more effectually than if he had set out to do it. This idea was dressed out in the atomistic psychology which Hartley built out from Locke—and returned at usurious rates to later economists.

From the great French writers who had sought to justify and promote democratic individualism, came the conception that, since it is perverted political institutions which deprave individuals and bring them into hostility, nation against nation, class against class, individual against individual, the great political problem is that reform of law and legislation, civic and criminal, of administration, and of education which will force the individual to find his own interest in pursuits which conduce to the welfare of others.

Tremendously effective as a tool of criticism, operative in abolition and elimination, utilitarianism failed to measure up to the constructive needs of the time. Its theoretical equalization of the good of each with that of every other was practically perverted by its excessive interest in the middle and manufacturing classes. Its speculative defect of an atomistic psychology combined with this narrowness of vision to make light of the constructive work that needs to be done by the state, before all can have, otherwise than in name, an equal chance to count in the common good. Thus the age-long subordination of economics to politics was revenged in the submerging of both politics and ethics in a narrow theory of economic profit; and utilitarianism, in its orthodox descendants, proffered the disjointed pieces of a mechanism, with a monotonous reiteration that if looked at aright they form a beautifully harmonious organism.

Prevision, and to some extent experience, of this failure, conjoined with differing social traditions and ambitions, evoked German idealism, the transcendental morals of Kant and his successors. German thought strove to preserve the traditions which bound culture to the past, while revising these traditions to render them capable of meeting novel conditions. It found weapons at hand in the conceptions borrowed by Roman law from Stoic philosophy, and in the conceptions by which protestant humanism had re-edited scholastic catholicism. Grotius had made the idea of natural law, natural right and obligation, the central idea of German morals, as thoroughly as Locke had made the individual desire for liberty and happiness the focus of English and then of French speculation. Materialized idealism is the happy monstrosity in which the popular demand for vivid imagery is most easily reconciled with the equally strong demand for supremacy of moral values; and the complete idealistic materialism of Stoicism has always given its ideas a practical influence out of all proportion to their theoretical

vogue as a system. To the Protestant, that is the German, humanist, Natural Law, the bond of harmonious reason in nature, the spring of sociable intercourse among men, the inward light of individual conscience, united Cicero, St. Paul and Luther in blessed union; gave a rational, not superrational basis for morals, and provided room for social legislation which at the same time could easily be held back from too ruthless application.

Kant clearly saw the mass of empirical and hence irrelevant detail that had found refuge within this liberal and diffusive reason. He saw that the idea of reason could be made self-consistent only by stripping it naked of these empirical accretions. He then provided, in his critiques, a somewhat cumbrous moving van for transferring the resultant pure or naked reason out from nature and the objective world, and for locating it in new quarters, with a new stock of goods and new customers. The new quarters were particular subjects, individuals; the stock of goods were the forms of perception and the functions of thought by which empirical flux was woven into durable fabrics; the new customers were a society of individuals in which all are ends in themselves. There ought to be an injunction that Kant's saying about Hume's awakening of him should never be quoted save in connexion with his other saying that Rousseau brought him to himself, in teaching him that the philosopher is of less account than the laborer in the fields unless he contributes to human freedom. But none the less, the new tenant, the universal reason, and the old homestead, the empirical tumultuous individual, could not get on together. Reason became a mere voice which having nothing in particular to say, said Law, Duty, in general, leaving to the existing social order of the Prussia of Frederick the Great the congenial task of declaring just what was obligatory in the concrete. The marriage of freedom and authority was thus celebrated with the under-

standing that the sentimental primacy went to the former and the practical control to the latter.

The effort to force a universal reason which had been used to the broad domains of the cosmos into the cramped confines of individuality conceived as merely "empirical," a highly particularized creature of sense, could have but one result: an explosion. The products of that explosion constitute the Post-Kantian philosophies. It was the work of Hegel to attempt to fill in the empty reason of Kant with the concrete contents of history. The voice sounded like the voice of Aristotle, Thomas of Aquino and Spinoza translated into Swabian German; but the hands were as the hands of Montesquieu, Herder, Condorcet and the rising historical school. The outcome was the assertion that history is reason, and reason is history: the actual is rational, the rational is the actual. It gave the pleasant appearance (which Hegel did not strenuously discourage) of being specifically an idealization of the Prussian nation, and incidentally a systematized apologetics for the universe at large. But in intellectual and practical effect, it lifted the idea of process above that of fixed origins and fixed ends, and presented the social and moral order, as well as the intellectual, as a scene of becoming, and it located reason somewhere within the struggles of life.

Unstable equilibrium, rapid fermentation and a succession of explosive reports are thus the chief notes of modern ethics. Scepticism and traditionalism, empiricism and rationalism, crude naturalisms and all embracing idealisms, flourish side by side—all the more flourish, one suspects, because side by side. Spencer exults that natural science reveals that the rapid transit system of evolution is carrying us automatically to the goal of a perfect man in a perfect society; and his English idealistic contemporary is so disturbed by the removal from nature of its moral quali-

ties, that he tries to show that it makes no difference, since nature in any case is known through a spiritual principle which is as permanent as nature is changing. An Amiel genteelly laments the decadence of the inner life, while his neighbor Nietzsche brandishes in rude ecstasy the banner of brute survival as a happy omen of the final victory of nobility of mind. The reasonable conclusion from such a scene is that there is taking place a transformation of attitude towards moral theory rather than mere propagation of varieties among theories. The classic theories all agree in one regard. They all alike assumed the existence of *the end*, the *summum bonum*, the final goal; and of *the separate moral force* which moves to that goal. Moralists have disputed as to whether the end is an aggregate of pleasurable state of consciousness, enjoyment of the divine essence, acknowledgment of the law of duty, or conformity to environment. So they have disputed as to the path by which the final goal is to be reached: fear or benevolence? reverence for pure law or pity for others? self-love or altruism? But these very controversies imply that there was but the one end and the one means.

The transformation in attitude, to which I referred, is the growing belief that the proper business of intelligence is discrimination of multiple and present goods and of the varied immediate means of their realization; not search for the one remote aim. The progress of biology has accustomed our minds to the notion that intelligence is not an outside power presiding supremely but statically over the desires and efforts of man, but that it is a method of adjustment of capacities and conditions within specific situations. History, as the lecturer on that subject told us, has discovered itself in the idea of process. The genetic standpoint makes us aware that the systems of the past are neither fraudulent imposture nor absolute revelations; but are the products of political, economic and scientific condi-

tions whose change carries with it change of reflective formulations. The recognition that intelligence is properly an organ of adjustment in difficult situations makes us aware that these past theories were of value so far as they helped carry to an issue the social perplexities from which they emerged. But the chief impact of the evolutionary method is upon the present. Theory having learned what it cannot do, is made responsible for the better performance of what needs to be done, and what only a broadly equipped intelligence can do: to study the conditions out of which come the obstacles and the resources of adequate life, and to develop and test the ideas which, as working hypotheses, may be used to diminish the causes of evil and buttress and expand the sources of good. This program is indeed vague, but only unfamiliarity with it could lead one to the conclusion that it is less vague than the idea that there is a single moral ideal and a single moral motive force.

From this point of view there is no separate body of moral rules; no separate system of motive powers; no separate subject-matter of moral knowledge, and hence no such thing as an isolated ethical science. If the business of morals is not to speculate upon man's final end, and upon an ultimate standard of right, it is to utilize physiology, anthropology and psychology to discover all that can be discovered of man, his organic powers and propensities. If its business is not to search for the one separate moral motive, it is to converge all the instrumentalities of the social arts, of law, education, economics and political science upon the construction of intelligent methods of improving the common lot.

If we still wish to make our peace with the past, and to sum up the plural and changing goods of life in a single word, doubtless the term happiness is the one most apt. But we should again exchange free morals for sterile meta-

physics, if we imagine that "happiness" is any less unique than the individuals who experience it; any less complex than the constitution of their capacities, or any less variable than the objects upon which their capacities are directed.

To many timid, albeit sincere, souls of an earlier century, the decay of the doctrine that all true and worthful science is knowledge of final causes seemed fraught with danger to science and to morals. The rival conception of a wide open universe, a universe without bounds in time or space, without final limits of origin or destiny, the universe with the lid off, was a menace. We now face in moral science a similar crisis and like opportunity, as well as share in a like dreadful suspense. The abolition of a fixed and final goal and causal force in nature did not, as matter of fact, render rational conviction less important or less attainable. It was accompanied by the provision of a technique of persistent and detailed inquiry in all special fields of fact, a technique which led to the detection of unsuspected forces and the revelation of undreamed of uses. In like fashion we may anticipate that the abolition of *the* final goal and *the* single motive power and *the* separate and infallible faculty in morals, will quicken inquiry into all the diversity of specific goods of experience, fix attention upon their conditions and bring to light values now dim and obscure. The change may relieve men from responsibility for what they cannot do, but it will promote thoughtful consideration of what they may do and the definition of responsibility for what they do amiss, because of failure to think straight and carefully. Absolute goods will fall into the background, but the question of making more sure and extensive the share of all men in natural and social goods will be urgent, a problem not to be escaped or evaded.

Morals, philosophy, returns to its first love; love of the wisdom that is nurse, as nature is mother, of good. But it returns to the Socratic principle equipped with a multitude

of special methods of inquiry and testing; with an organized mass of knowledge, and with control of the arrangements by which industry, law and education may concentrate upon the problem of the participation by all men and women, up to their capacity of absorption, in all attained values. Morals may then well leave to poetry and to art, the task (so unartistically performed by philosophy since Plato) of gathering together and rounding out, into one abiding picture, the separate and special goods of life. It may leave this task with the assurance that the resultant synthesis will not depict any final and all inclusive good, but will add just one more specific good to the enjoyable excellencies of life.

Humorous irony shines through most of the harsh glances turned towards the idea of an experimental basis and career for morals. Some shiver in the fear that morals will be plunged into anarchic confusion—a view well expressed by a recent writer in the saying that if the *a priori* and transcendental basis of morals be abandoned “we shall have merely the same certainty that now exists in physics and chemistry”! Elsewhere lurks the apprehension that the progress of scientific method will deliver the purposive freedom of man bound hand and foot to the fatal decrees of iron necessity, called natural law. The notion that laws govern and forces rule is an animistic survival. It is a product of reading nature in terms of politics in order then to turn about and read politics in the light of supposed sanctions of nature. This idea passed from medieval theology into the science of Newton, to whom the universe was the dominion of a sovereign whose laws were the laws of nature. From Newton it passed into the deism of the eighteenth century, whence it migrated into the philosophy of the Enlightenment, to make its last stand in Spencer’s philosophy of the fixed environment and the static goal.

No, nature is not an unchangeable order, unwinding

itself majestically from the reel of law under the control of deified forces. It is an indefinite congeries of changes. Laws are not governmental regulations which limit change, but are convenient formulations of selected portions of change followed through a longer or shorter period of time, and then registered in those statistical forms which are amenable to mathematical manipulation. That this device of shorthand symbolization presages the subjection of man's intelligent effort to fixity of law and environment is interesting as a culture survival, but is not important for moral theory. Savage and child delight in creating bogeys from which, in concealing their origin and structure, interesting thrills and shudders may be had. Civilized man in the nineteenth century outdid these bugaboos in his image of a fixed universe hung on a cast-iron framework of fixed, necessary and universal laws. Knowledge of nature does not mean subjection to predestination, but insight into courses of change; an insight which is formulated in "laws," that is, methods of subsequent procedure.

Knowledge of the process and conditions of physical and social change by experimental science and genetic history has one result with a double name: increase of control and increase of responsibility; increase of power to direct natural change, and increase of responsibility for its equitable direction toward fuller good. Theory located within progressive practice instead of reigning statically supreme over it, means practice itself made responsible to intelligence; to intelligence which relentlessly scrutinizes the consequences of every practice, and which exacts liability by an equally relentless publicity. As long as morals occupies itself with mere ideals, forces and conditions as they are will be good enough for "practical" men, since they are then left free to their own devices in turning these to their own account. As long as moralists plume themselves upon pos-

session of the domain of the categorical imperative with its bare precepts, men of executive habits will always be at their elbows to regulate the concrete social conditions through which the form of law gets its actual filling of specific injunctions. When freedom is conceived to be transcendental, the coercive restraint of immediate necessity will lay its harsh hand upon the mass of men.

In the end, men do what they can do. They refrain from doing what they cannot do. They do what their own specific powers in conjunction with the limitations and resources of the environment permit. The effective control of their powers is not through precepts, but through the regulation of their conditions. If this regulation is itself to be not merely physical or coercive, but moral, it must consist of the intelligent selection and determination of the environments in which we act; and in an intelligent exaction of responsibility for the use of men's powers. Theorists inquire after the "motive" to morality, to virtue and the good, under such circumstances. What then, one wonders, is their conception of the make-up of human nature and of its relation to virtue and to goodness? The pessimism which dictates such a question, if it be justified, precludes any consideration of morals.

The diversion of intelligence from discrimination of plural and concrete goods, from noting their conditions and obstacles, and from the task of devising methods for holding men responsible for their concrete use of powers and conditions, has done more than brute love of power to establish inequality and injustice among men. It has done more, because it has confirmed with social sanctions the principle of feudal domination. All men require moral sanctions in their conduct: the consent of their kind. Not getting it otherwise, they go insane to feign it. No man ever lived with the exclusive approval of his own conscience. Hence the vacuum left in practical matters by the remote

irrelevancy of transcendental morals has to be filled in somehow. It is filled in. It is filled in with class-codes, class-standards, class approvals—with codes which recommend the practices and habits already current in a given circle, set, calling, profession, trade, industry, club or gang. These class-codes always lean back upon and support themselves by the professed ideal code. This latter meets them more than half-way. Being in its pretence a theory for regulating practice, it must demonstrate its practicability. It is uneasy in isolation, and travels hastily to meet with compromise and accommodation the actual situation in all its brute unrationality. Where the pressure is greatest—in the habitual practice of the political and economic chieftains—there it accommodates the most.

Class-codes of morals are sanctions, under the caption of ideals, of uncriticized customs; they are recommendations, under the head of duties, of what the members of the class are already most given to doing. If there are to obtain more equable and comprehensive principles of action, exacting a more impartial exercise of natural power and resource in the interests of a common good, it will be because members of a class can no longer rest content in responsibility to a class whose traditions constitute its conscience, but are made responsible to a society whose conscience is its free and effectively organized intelligence.

In such a conscience alone will the Socratic injunction to man to know himself be fulfilled.

PHILOLOGY

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART
APRIL 1, 1908**



PHILOLOGY

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COLUMBIA UNIVERSITY**

New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published June, 1908.

PHILOLOGY

"WORDS, words, words," said Hamlet once, and it may seem to some who are less informed on the subject, that philology is a science that deals merely with words. Such is not the case. And if it were so, those "mere words," so rich in associations of the past, are trophies worthy to be enshrined as precious relics, since they represent proud triumphs of the human mind won in intellectual battles through the ages. The true philologist is not a mere student of language; he must be more if he fulfils the duties of his office. While engrossed in the most exact details of the smallest word, the least syllable, the seemingly insignificant letter, or the minutest fraction of a sound that his knowledge enables him to analyze, he must be prepared to become in turn the historian, philosopher and logician, the physiologist, psychologist and sociologist, and even the student of comparative religion, and with it all he must ever remain the skilled observer and impartial judge. Such are the ideals of the true philologist.

Interest in the field of philological research has grown steadily and healthily. A glance through the pages of any good catalogue of publications in the linguistic line will reveal a list of two or three hundred titles of journals and transactions of learned societies devoted to a study of the subject, supplemented by a large number of general periodicals, special serials, and occasional linguistic reports, to say nothing of the countless single works, memoirs, and

monographs on philological themes, that annually appear not only in Europe and America, but also in Egypt, India, Java, China, and Japan. At this very time, moreover, we are watching the publication of a succession of immensely valuable "Grundrisse"—each devoted to a special group of Indo-European tongues and forming a rich storehouse of philological material that is encyclopedic in its character. Similar compendiums in other linguistic groups will follow.

Scholars, furthermore, come together each year in philological gatherings or assemble at stated intervals in international congresses that deal with the manifold sides of linguistic activity. It often happens, too, that questions of grave import turn upon matters that belong to the philologist to decide. The historian and theologian will best appreciate this fact. Not only this, but hardly a day passes without our having to turn to that special monument of the philologist's labor, the dictionary, for information on some matter of spelling, definition, or derivation; and the number of these standard works and special lexicons, like the vast number of words they contain, is ever on the increase. We need only allude to the great lexicographical monuments which France, Germany, England, and America have produced within the last thirty years. Language, moreover, that globe-encircling chain, has a universal interest because of the rôle it has played in developing human society. If all knowledge was Bacon's sphere, all languages are the philologist's domain. Nothing that relates to them can therefore be foreign to his or our interests.

The use of the term "philology," like most of such designations, is a relative one. In its proper sense the word is understood to connote everything that finds its expression through the medium of language, and it is as applicable to literary forms as to spoken speech. This is the broad

significance which German and French scholars commonly assign to the word; and, indeed, it is the preferable one. But there has grown up in England, as also in America and elsewhere, a tendency to narrow and restrict the meaning of "philology" to denote that which is otherwise called "comparative philology," "comparative grammar," "science of language," or, in general, "linguistics." This narrowing of the application of the word has its advantages; but, let me emphasize again, the broader comprehension of the term is the more correct one, and is more in keeping with the scope of the philologist's vision.

The possession of language, that divine gift universally belonging to mankind, is recognized as having been probably the most potent factor in advancing human institutions and the world's civilization. Although everything that embodies thought, whether in the form of art, music, sculpture, or other symbolic or graphic representation, is indeed language, in that it is a means of communication, nevertheless the particular theme of the philologist—to use the word in the restricted sense—is the science of speech, whether uttered or recorded. It is this gift of language that most strikingly distinguishes man from the brute and which makes men (to quote Hamlet again) "the paragon of animals." Not that any one for an instant denies that animals communicate with each other by cries and signs and thus give expression to their feelings, but such utterances, called forth by instinct, differ *toto caelo* from the speech of man inspired by reason. It must be admitted that the attempts that have been made by linguistic investigators to analyze or synthesize into articulate speech the rudimentary communications of the chimpanzee or some other member of the lower creation have thus far, at least, failed to supply one of the missing links in the Darwinian chain of evidence. There still remains this impassable barrier to surmount, this dividing gulf to cross. It is true that

some investigators, following the example of Garner, are at work upon "monkey vocabularies" and "simian dialects," but as yet their results are not such that they can claim to be of real scientific value.

As the scientist well knows, language is pre-eminently a means to an end. The aim in view is the desire to communicate with others and to understand them in return. As a means to achieving this end it is easy to recognize how the human voice triumphed over gesture and grimace, and rose paramount as the fittest and best suited instrument to accomplish the task. I need only add that this exquisitely adapted implement, the *vox humana*, has become more and more perfected in the course of ages until its capability and efficiency, aided at times by its handmaidens, gesticulation and facial expression, seem infinite. So wonderful is its power and so miraculous the gift which it imparts that philosophers, since the days of the Greeks, have not ceased to speculate on the origin of language, whether it be God-given, adopted by imitation, evolved from ejaculations, or otherwise brought into existence. But we may safely declare that no onomatopoeic, or "bow-wow" hypothesis, no "pooh-pooh" or "ding-dong" theory, no "yo-he-ho" or "love and song" explanation (to use the catchwords of Max Müller and other investigators of the problem), nor in fact any other proposed solution, has afforded a complete answer to the enigma of how speech began. It is true that each of the numerous suggestions since Herder's day has something in its favor, yet the problem is too complex, and the combination-lock that safeguards the treasured secret is too intricate to be opened by a single key. In any case we must concede that language had its beginning at least as early as the beginning of organized society; it is a socio-historical product and the offspring of necessity. The study of language falls within the realm of social science.

The science of comparative philology is young in years—although the oldest, I believe, among the comparative sciences, except comparative anatomy—but in its relatively short lifetime it has contributed liberally to the advancement of kindred sciences through the methods of research it had adopted in advance of them and the results which it has been able to accomplish. A century has hardly elapsed since the time when philology came into being. So quick was its birth and so rapid its growth that it seemed to have sprung Minerva-like from the head of a Zeus. Yet this science does not owe its origin either to Greece or Rome, although the literature of the classic lands contributed to its nurture. Comparative philology owes its origin to a gift from far-off India. It is true that Plato's "Cratylus" has still a remote interest for the student of etymology, and that the Greek grammarians of Alexandria or their Roman counterparts, Varro and Priscian, may be cited as quasi-pioneers when we are giving a historical sketch of philological studies. It is equally true that Arabic literature, from the seventh century onward, can point to more than two thousand writers (many of them Persians by birth) who dealt with grammatical, lexicographical, and philological subjects. It is a fact, likewise, that the Jews had their Massoretic scholiasts and a line of Hebrew grammarians dating from the tenth and the eleventh century of our era. Nevertheless, none of these efforts in single directions produced comparative philology, although, like similar endeavors in other lines, they may have accomplished something. Comparative philology was born on the day when Sanskrit was opened to the eyes of the Western world. The enthusiasm that stirred the hearts of those first pioneers into the realm of India's sacred language and India's ancient lore still throbs in the veins of their followers to-day and will quicken the pulse-beat of inspired workers for generations to come. We may laugh,

to be sure, at the old etymology of the word for "meat" in the Law Code of Manu: "He will me-eat (*māmsa*) in yonder world whose me-eat (*māmsa*) I eat in this world here, for that is the whole meat of the matter." Or we may be amused because the ancient Brahmans called a "prop" a "propper" because it was "proper." We are reminded of some of the etymological attempts of the Greeks, or of the jocular derivation of "ostler" by Dean Swift from "oat-stealer." But we cannot withhold our admiration from old Yaska of India, that earliest of all philologists—for he lived about the fifth century B. C.—nor can we refrain from lauding the great Sanskrit grammarian Panini, who wrote about 300 B. C., or from praising his long line of successors beginning with Katyayana, even if we look askance at some of their grammatical foibles and eccentricities, or be disappointed at their failure to know all that we know. It was they who taught us the scientific analysis of a word into root, stem, and suffix; it was they who knew secrets of speech that the Greeks never had divined.

It was Sir William Jones who first drew public attention more widely to the value of Sanskrit in the special matter of determining the relationship of various groups of languages in Asia and Europe, now comprised under the general name of Aryan, Indo-Germanic or Indo-European, since they include the great linguistic families of India, Persia, Armenia, and of the Greeks, Romans and Kelts, the Teutons and the Slavs. Though the note had previously been struck by other scholars, it was the chord sounded by him in his presidential address before the Asiatic Society at Calcutta in 1786 (published two years later) that has echoed on till to-day.

"The Sanskrit language," said Sir William, "whatever be its antiquity, is of wonderful structure; more perfect than the Greek, more copious than the Latin, and more exquisitely refined than either; yet bearing to both of them

a stronger affinity, both in the roots of verbs and in the forms of grammar, than could have been produced by accident; so strong that no philologist could examine all three without believing them to have sprung from some common source, which perhaps no longer exists. There is a similar reason, though not quite so forcible, for supposing that both the Gothic and Celtic, though blended with a different idiom, had the same origin with the Sanskrit."

To Germany, however, belongs the honor of producing the true founders of the new comparative science at the opening of the nineteenth century—and Germany still holds the foremost rank in the field. It was Franz Bopp, that man of many languages and unbounded patience, who became the real leader by showing with laudable exactness the general relationship that exists between the members of the great group of languages in Europe and their Asiatic cousins, the languages of India and Persia. It was he, likewise, that led the way by proposing a theory (sufficiently open to attack later) to explain the origin of the endings and formative elements in these highly inflected tongues.

The second name is well known to every one here present; it is the name of Jakob Grimm. We all must agree that there is a special charm in associating the personality of this philologist with that delight of our childhood, Grimm's Fairy Tales, the work of Jakob and his brother Wilhelm—the Brothers Grimm, as we call them. There was something of the enchanter's wand in Jakob Grimm's magical power to call forth that which could be divined only by an inspired imagination. His great work dealing with the Germanic languages as a single group in the larger Indo-European family made him the founder of historical grammar, as Bopp was of comparative philology. Grimm, likewise, became the Newton of the science of language by his wonderful discovery of the law of per-

mutation of consonants, known by his name, even if Rask, the Dane, had previously blazed out a part of the path. Minds of the divining and prophetic character of a Grimm entitle philology to the high rank which it enjoys among sciences.

Scientific etymology, as the next branch of comparative philology, owes its origin to August Friedrich Pott (1802-87). Pott did more than any one else in the first half of the nineteenth century to remove the stigma of the old jibe of Voltaire that "Etymology is a science in which the vowels count for nothing and the consonants for very little."

When the time was ripe for an organizing spirit, it found its expression in Schleicher, who brought the growing science to a high degree of advancement by his remarkable "Compendium," first published in 1861, in which he presented a portrait sketch of each member of the Indo-European family, with an outline picture of the face of the Aryan mother in the background. Like the modern results of composite photography, the images were in many respects imperfect and the likeness by no means wholly satisfactory, as we may best judge from the recent strictures by Oertel on the whole subject of such theoretic reconstructions. Schleicher's views, moreover, on the subject of language as a natural science (he himself was a natural scientist) have long since proved untenable; and certain of his philosophic tenets in regard to language, which Streitberg ("Indogermanische Forschungen" 7. 360-372) has proved beyond doubt to have been tinged by Hegelianism, can no longer be maintained; nevertheless, no one to-day would hesitate to accord to Schleicher philological honors of the highest kind.

Were it possible within the hour allowed for these Wednesday non-technical lectures, it would be an acceptable task to present and summarize the contributions of a dozen

other pioneers, like the two Schlegels, Benfey in Sanskrit, Curtius in Greek, Corssen and Mommsen in Latin, Zeuss in Celtic, Miklosich in Slavic, Diez in Romance, and Scherer in Germanic, or again to estimate the valuable work accomplished by such men as the Italian Ascoli, the Frenchmen Burnouf and Bréal, the Dane Rask, or the brilliant Anglo-German Max Müller, or our own countryman Whitney, and the well-known Germans, Fick of Breslau, Johannes Schmidt of Berlin, Leskien of Leipzig, and also Collitz, whom we have been happy for the past twenty years to claim as an American professor.

A mere mention, however appreciative, will not suffice for summarizing the new era created in the seventies and early eighties by the Leipzig school known as the Junggrammaturker or Neo-Grammarians. This remarkable trend in the science was largely a reaction against certain of the older views that had been held by such men as Georg Curtius, and it was guided in the first instance by Leskien (himself an old pupil of Schleicher), who made the shibboleth of the new movement the "inviolability of sound-laws"—*die Ausnahmslosigkeit der Lautgesetze*. The struggle centered about a group of younger scholars, especially Osthoff, Paul, and Karl Brugmann—the latter, the author of the "Grundriss der vergleichenden Grammatik der indogermanischen Sprachen" (the first volume of which appeared in 1886) being universally recognized as the greatest living philologist. The whole movement which this younger generation of investigators created was coincident in part with the phenomenal advance made in the scientific study of the modern languages by the side of the classics; for the living tongues had gradually begun to assert their right and title to consideration by the side of the dead languages. The Neo-Grammarians proved themselves up-to-date in their readiness to draw illustrations from these as well as from ancient tongues; in their willingness to

abandon some of the old problems as insoluble in the light of our knowledge at the present time; in the sharp distinction they made between physical laws and sound-laws which admit of the action of the will; in their insistence on the likelihood of dialect-mixture as a factor in judging languages; and in their emphasis of the rôle played by analogy in the development of linguistic forms. It is impossible here to enter into details as to the various parts taken in this movement by men whose articles were contributed to "Kuhn's Zeitschrift," "Bezzenberger's Beiträge," and other German periodicals—for the battle was largely fought in Germany. The general status of the question to-day will be clear to any one who reads the recent volumes of the "Indogermanische Forschungen," edited by Brugmann and Streitberg, or who examines the articles contributed by any one of the exponents of the modern tendencies in the philological journals of France, England, and Italy, Denmark, Norway, and Sweden, or our own America. In the month of August next year, 1909, the twenty-fifth anniversary of Brugmann's professorship in the chair of Indo-Germanic languages will be celebrated by his many pupils and friends. A special volume of articles, contributed by his fellow-philologists and edited by his co-worker Streitberg, will be prepared in his honor.

In sketching the historical development so as to include the main results of the Neo-grammarian movement I have had to omit several steps that were of prime importance in the way of linguistic discoveries, but which may not be familiar at the moment to the audience here gathered. The first of these was a series of discoveries that led to the gradual clearing away of the so-called exceptions to Grimm's Law. Among the number of these finds was that made by the eminent mathematician and Sanskritist Hermann Grassmann, who showed that a number of ap-

parent violations of the law could be explained by assuming that the refractory roots in question both began and ended with an aspirate in the original Indo-European. Of unmatched importance, however, was the discovery made in 1877 by Karl Verner, the Dane, that accent exercised a paramount influence in determining the nature of sound-shifts in the Germanic tongues. This particular enunciation, together with Ascoli's exposition, in 1870, of the composite character of the original *k*-sound, elaborated further by Collitz and others, together with Brugmann's remarkable postulation of the law of the nasal sonant, almost entirely did away with the old-fashioned notion of "sporadic change" so far as the consonants were concerned, and established on a firmer basis than ever before the doctrine that sound-laws have no exception. On the consonantal side, therefore, there has been little to add since those days, except in matters of further detail.

The vowels, on the other hand, which had "counted for nothing" in the time of Voltaire, were still under the ban. The true recognition of their value was brought about slowly through a succession of investigations that followed in the train of Curtius's "*Spaltung des a-Lautes*" (1865). These researches were carried on mainly by Amelung, Osthoff, Brugmann, Collitz, Johannes Schmidt, Hübschmann, and particularly by Mahlow, "*Die langen Vocale a, e, o, in den europäischen Sprachen*" (1879), and by the Swiss philologist, Ferdinand de Saussure, whose "*Mémoire sur le système primitif des voyelles*" (1879) still ranks as a masterpiece in philological work. Since that era the most important contributions to the theory of Indo-European vocalism have been those made by Bartholomae, Bechtel, Fortunatov, Meillet, Brugmann, and Streitberg, and especially the studies of accent and its relation to vowel gradation made by Hermann Hirt in his "*Indogermanischer Akzent*" (1895) and "*Indogermanischer*

Ablaut" (1900). There still remains, nevertheless, much to elucidate in the whole subject of vowel-variation and accentuation, and the field promises to be a fruitful one to work.

This discussion of the operation of phonological laws leads us to speak of another branch of philology which has made remarkable strides in the past half-century. I refer to the science of phonetics. Not that this is an entirely new science, since the Hindu phoneticians more than two thousand years ago analyzed sounds with an accuracy that still excites the admiration of present-day observers; but as a branch of science phonetics was little cultivated in the West until the middle of the last century. The way had indeed been opened by the work done by the pioneer philologists down to the time of Pott and Benfey. An imposing array of phonetic formulas had been drawn up, and gradually arrangement and discipline triumphed over confusion and lawlessness; well defined rules of sound-change banished arbitrary license. But it remained for special investigators to establish a better understanding of the true nature of sounds and their production, and to define the function of the acoustic, or receptive, side of speech. This was the rôle of phonetics, and in advancing this new branch of linguistic science the modern languages had a distinguished share.

As promoters of these investigations, the anatomist and physicist have joined hands with the linguist and worked side by side with him. In this respect the names of Brucke, Merkel, Donders, Helmholtz, Ellis, Evans, Trautmann, Techmer, Sweet, Sievers, Meillet, and Rousselot, and, in our country, Bell and Scripture, are conspicuous above the rest. The mechanism of the organs which produce speech have been examined anatomically from the phonetic standpoint with an ever-growing precision. Cleverly devised appliances, such as the artificial palate and kindred con-

trivances that enable the investigators to mark more exactly the position of the tongue in pronouncing each given sound, have passed into fairly common usage among those who deal with the speech-production side of phonetics. On the acoustic side remarkable researches have been carried on along the line of experimental phonetics, and among these I would make particular mention of the series of investigations into speech-curves conducted lately by the American phonetician E. W. Scripture, whose most recent contribution to the general subject will be found in the publications of the Carnegie Institution at Washington. Delicately constructed instruments plot the curves of vibrations produced by speech-sounds; and these vibrations, measured with the utmost precision now possible, are transposed into elements of time. The result of these transferences are of the greatest interest to the physicist and physiologist, as I know best from my friend and colleague, Professor Hallock of Columbia, who has worked in similar fields. But the philologist has not yet fully utilized the results of these investigations, although their importance is duly recognized, and we may predict that a remarkable advance will be made along this line within the next ten or fifteen years, when the achievements in this special branch have become more generally accessible. It must not be overlooked that the growing number of special phonetic journals in various languages tends to broaden the knowledge of the subject in every direction. One phase of phonetic activity, I may mention before leaving the topic, has assumed considerable proportions in this country in the form of phonetic rules applied to the simplification of English spelling. The establishment of a Simplified Spelling Board I count as a hopeful sign in that direction.

On the special side of language as an expression of thought, the philosophical speculations of the older days of

a Herder or a Lazarus Geiger have given place rather to the study of linguistic psychology—in other words, a Steinthal has been succeeded by a Wundt with his “Völkerpsychologie” (1900), with its investigation into the psychology of peoples judged from the standpoint of language. As has been admirably remarked by a well-known American philologist, “one of the chief characteristics of the language-study of the last fifty years is the increased attention paid to the psychological factors in language, and never has the relation between linguistics and psychology been so close as at the present” (a statement by Buck in an address on “The Relations of Comparative Grammar” delivered at the Congress of Arts and Science at St. Louis in 1904). This is indicated, for example, by the attention that has been given to comparative studies in respect to the differences shown by individual languages in their manner of expressing grammatical relations; or again by special studies of vocabulary as representing modes of thought; or by researches into the nature of semantic phenomena as an intimation of the development of the meanings of words; or, finally, by estimating the functions of analogy in language with its various phases of the associative process. Not only that, but the pathological aspects of language, linguistic disturbances and disorders of speech, are to-day receiving more and more scientific consideration by the philologist. Cases of aphasia, or the various forms of inability to produce articulate speech; of paraphasia, or word-confusion; of apraxia manifested in a failure to recognize the import of designation; and of sensory aphasia, a kind of word-deafness and word-blindness—all these are phenomena closely observed nowadays by specialists in the realm of experimental psychology, and considerable progress has been made in this manner toward localizing the speech-centers and determining the language-functions of the brain.

Reference has already been made to the possession of language as a universal human quality; no race existing has been found to be without it. The number of different languages consequently runs up to the thousands; a glance at the comprehensive work of Friedrich Müller, "Grundriss der Sprachwissenschaft" (1876-87) will be convincing on this point; and if we include dialects, whether that term be understood in a strictly scientific sense or construed in a liberal manner, the number will be increased ten-fold. This wide-spread distribution of tongues over the globe and their divergent character make the problem of classification a difficult one. No thoroughly satisfactory classification has yet been found, but the genetic grouping thus far has proved to be the more practical, even if the philologist, anthropologist and ethnologist agree that language is not, strictly speaking, a sign of race or a proof of blood-affinity among peoples. The genetic classification has long been the accepted one, and, so far as my knowledge goes, there is no occasion to depart from it as a convenient working hypothesis, though it must never be erected into a philological dogma.

The most remarkable change and advance in the general philological situation within our lifetime is the advance that has been made by admitting not only the modern languages to a position beside the classics, but also by opening the door to the other great language groups of the world, especially the Asiatic, as entitled to a place among the regular forms of discipline recognized in education. The broadening of the horizon in this respect has been remarkable. Sufficient allusion has already been made to the influence that was exerted upon language studies when Sanskrit first became known. Hebrew, among other Semitic tongues, had already received occasional recognition in collegiate institutions as well as theological seminaries, because of its just claims to importance for Biblical studies.

The gradual advance of Semitics, especially the rapid strides made in the study of Assyrian, Babylonian, Syriac, Arabic, and other Semitic tongues, followed as a sequel to the opening up of new materials from the Orient. Although Semitic philology is comparatively in its infancy, the pioneer work done by de Sacy, Gesenius, Ewald, Delitzsch, Wright, Lagarde, and Nöldeke, has been carried forward by Haupt, Zimmern, Barth, and others, and this very day a large work by Brockelmann on the comparative grammar of the Semitic languages ("Grundriss der vergleichenden Grammatik der semitischen Sprachen") is in course of publication in Leipzig. The recent discoveries of ancient Jewish documents, moreover, made by English, French, and German savants conducting excavations in Egypt promise to be important for philological studies as well as for Biblical history in the times of Ezra and Nehemiah, since they preserve, among other things, records of a petition from the priests of the temple of Jehovah to Bagoas, the Persian governor of Jerusalem under Darius Nothus. New light may be thrown by these monuments of the past upon the relations existing between the Jews and the Persians in early times. Winckler's recent finds of Indian and Iranian names among Hittite remains in Asia Minor are likely to prove epoch-making. I may add in passing that the old time philological attempts to show a relationship between the Semitic and Aryan tongues have not failed to exercise a fascination for those who are linguistically inclined; the very latest of these endeavors is by Pedersen in the current number of the "Indo-germanische Forschungen."

Among the languages of Africa, the Egyptian has not ceased to be studied since the days of the discovery of the famous Rosetta Stone. The names of Champollion, of Lepsius, de Rouge, Brugsch, Ebers, Maspero, Piehl, and Flinders Petrie have been supplemented by Erman, the

distinguished Egyptologist of Berlin, who introduced the historical method in the study of Egyptian, and he has been ably seconded by our American Breasted of Chicago, and W. Max Müller of Philadelphia. Among the number of linguistic workers on Koptic, Stern and Steindorff—both Germans—may be mentioned; and there are earnest scholars, like Reinisch, Bleek, Steinthal, Krapf, Koelb, Torrend, engaged in investigating the other African tongues, but the entire field needs more cultivation before rich fruits may be expected, and it is to be wished that more universities may follow the lead already made by several in establishing chairs of Egyptology, and by making better provision for the general study of the languages of the land between the Mediterranean and the Cape of Good Hope. I must not neglect to add that a special periodical for the study of African languages—“*Zeitschrift für afrikanische Sprachen*”—was started in 1887 and has been succeeded by another which was founded in 1895, by Seidel of Berlin, to include likewise the Oceanic languages with the African.

China has fared reasonably well philologically, considering the fact that attention is not always given ungrudgingly to distant lands. She has had her Stanislas Julien, Williams, Legge, and Schlegel, and still may claim her Giles, Georg von der Gabelentz, Chavannes, and our colleague Hirth. The growth of interest in the Celestial Empire has been so marked that to-day chairs in Chinese are admitted to an equal share in the honors accorded to other Asiatic claimants in certain of the universities of Europe and America. The languages of Japan, Korea, Tibet, Turkistan, Central and Northern Asia, the problematic Hittite and Sumero-Accadian, as well as the old tongues in Mexico and South America have each their devoted specialists, whose yeoman service is being appreciated more and more as the rapid advance in intercourse between na-

tions brings these various regions into closer touch with our present interests. The same is true of the various Polynesian tongues, and our own country's interest in Oceanic languages is no longer remote since the day of the battle of Manila, when the Philippines came into the possession of the United States. For that reason, studies of the Philippine dialects are for us to-day no longer an out-of-the-way subject, but a near-at-hand theme, as shown, for example, by the active work done in the field by Blake and others, including Conant, since 1898.

Speaking of America naturally leads to a special mention of the interest that is being taken in the study of the languages of the American Indians. Ever-increasing scientific attention has been given to the subject within the last half century by such workers as Gallatin, Brinton, Gatschet, Kleinschmidt, Dorsey, and our Columbia professor, Boas, so that the investigation of the linguistic stocks of the New World forms a special branch of philological research in several learned institutions both at home and abroad. Within the next few years, moreover, we may look for a "Handbook of the Languages of the American Indians north of Mexico," already announced to be in the course of preparation by the Bureau of Ethnology at Washington.

The relation which the science of language bears to other branches of scientific study has been indicated more than once in the course of this address, even if no time was allowed to elaborate upon the points; and there now remain only a few minutes to touch upon some of the advances made, and to mention some of the present tendencies and problems in philology. Among the departments in which marked progress has been made is that of comparative syntax as a special branch of philological science. The name of Delbrück, a collaborator of Brugmann, stands pre-eminently forth in this division, and he has had

the ablest backing from scores of specialists in the allied fields.

In the range of comparative metrics similar advances have been made in specialized lines since the time of Westphal, until to-day the Germanist Sievers, no longer content to confine his contributions to the realm of Teutonic rhythm, has gone forward to discuss the minutiae of Sanskrit meters in the Veda, and has even published an extensive series of investigations on the subject of Hebrew versification. From the same gifted philologist, who is competent in so many fields, we may also look for some interesting deductions with regard to the general topic of the rhythm of prose.

The study of the meaning of words in different languages (a branch of paramount importance in lexicography) has led to another specialized phase of philological research known as semasiology, or semantics, in which the name of the French scholar Bréal stands in the foreground.

Certain other aspects of philology and the application of its results are familiar to the student of mythology, ethnology, anthropology, sociology, and comparative religion, as already indicated. The importance, for example, of Schrader's contributions in the line of prehistoric Indo-Germanic antiquities and the early civilization of Europe is not easy to overestimate, even when presented in its newest form in his "Reallexikon der indogermanischen Altertumskunde" (1901). Somewhat kindred in their nature are Hirt's "Die Indogermanen" (two volumes, 1905-7) and Meringer's contributions on the subject of "Wörter und Sachen" that have appeared in the "Indogermanische Forschungen." If Victor Hehn's book, entitled "Kulturpflanzen und Haustiere," on the cultivated plants and domestic animals of Asia in relation to Europe, written nearly forty years ago, still remains a standard work, because of the admirable manner in which its mate-

rial was treated from the comparative standpoint, we may place beside it the second edition of Mannhardt's "Wald- und Feldkulte" (1905) and Hoops's "Waldbäume und Kulturpflanzen im germanischen Altertum" (1905), to both of which works the results of comparative philology have contributed conspicuously. It would be easy offhand to adduce a score or more of similar illustrations, like Adalbert Kuhn's "Herabkunft des Feuers" (2 ed. 1857) and de Gubernatis's "Zoological Mythology" (1872) and "Mythologie de plantes" (1878-82),—but enough!

Closely connected with researches of this character and always a subject of interest to the philologist is the question as to the location of the primitive home of the Indo-Germanic peoples. In the eyes of most philologists Asia has long since been forced to yield her claim to the distinction of having been the cradle of the Aryan race; instead of that, several different countries in Europe, from Sweden to the Caucasus, have put forward a claim through special pleaders as being entitled to the honor. At the present moment the plea urged by those in favor of the north of Europe seems to receive by far the most support; in fact, the two most recent works that touch on the subject (Much, "Die Heimat der Indogermanen," 1902, and Hirt, "Die Indogermanen," 1905-7) incline either toward the Western shore of the Baltic or toward the lowland regions of northern Europe that roughly correspond to a portion of the modern Empire of Germany.

The whole question of linguistic affinities already referred to when mentioning Semitics in connection with Indo-European seems still to linger in the air but to be no nearer solution than it was long ago. In a semi-popular but suggestive primer on the "History of Language" (1900) the English scholar Sweet, for example, throws down the gauntlet for his fellow-linguists to take up, by an attempt to show that there are peculiar affinities

between Aryan languages and seemingly unrelated groups of Ugrian and Ural-Altaic tongues, as well as likenesses to the problematical Sumerian. It is only fair to add that Sweet frankly declared at the outset his anticipation of strong opposition to such a hypothesis, and, furthermore to state that our view of the question depends much upon our attitude toward the great problem of the descent of all languages, whether we seek to derive them from a common primeval language or from a number of independently evolved parent languages.

It is of peculiar interest in this connection to call attention to a matter that is likely to be followed by a train of linguistic surprises as well as by important results in other lines. I refer to the remarkable discoveries that have been made in Eastern Turkistan by the expedition of Grünwedel and Le Coq, sent out under the patronage of the Emperor of Germany. The wonderful finds that have been made in the sand-buried ruins of that district, like those previously unearthed by Stein, are of extraordinary significance not alone for history, archaeology, and art, but also for the various branches of philological studies, if we may judge from the specimens already made accessible by Pischel, F. W. K. Müller, Sieg, and Siegeling in the transactions of the Berlin Academy, and by Salemann in the Academy of St. Petersburg. The philologist will have a hard problem to solve, and will require additional help from his brothers in the allied sciences, when he comes to account for the paradoxical presence of a *centum*-language instead of a *satam*-language in the speech beyond the Oxus, or, in other words, to explain the anomalous presence in Asia of a tongue with the *k*-sound, which is characteristic of European languages in contrast to the palatal sibilant that distinguishes the Eastern Aryan group. Students of the history of art will find new treasures among these dust-heaps; while the student of relig-

ion may not only look for more light on Manichaeism, but may also find additional fragments of the New Testament rendered into the language of Sasanian Persia, besides those Pazand fragments which Müller has already edited.

Owing to the rapid strides made in linguistic studies during recent years, it is but natural to expect that views should constantly be undergoing change and that opinions which were current a few years ago should now be antiquated or be wholly rejected. On the other hand, many theories that have been attacked and seemingly supplanted for a time have ultimately proved their title to continued existence or to be allowed to stand alongside of the hypothesis that sought to replace them. Such a case, for example, may be found in that much mooted problem of the origin of Indo-European inflection. Why does the Sanskrit verbal conjugation of the verb "to bear" show *bhar-ā-mi*, *bhar-a-si*, *bhar-a-ti*, etc., which may be paralleled with the varied forms that express "I bear, thou bearest, he bears," in the different languages of the entire Aryan family? Bopp's old-time theory of the pronominal origin of these inflectional endings, though more or less current still in popular circles, has long since ceased to find general favor in the eyes of specialists, despite the fact that nothing really satisfactory has supplanted it. Hirt (IF 17. 36-84) has made a very plausible plea for the origin of verbal forms from the noun, and for the part played by ablaut in the development of formative elements, and he has supported his contention with great ingenuity; nevertheless, there still remains so much that is not explained, that his hypothesis, though containing undoubted germs of truth, fails to carry full conviction, although what is true in it must be combined with what is true in Bopp's theory till scholars supplement it and its other predecessors by casting new light on this dark subject.

The changes in special linguistic nomenclature strike every one who reviews the progress made during the past fifty years. Instead of employing the terms "prefixes," "suffixes," and "affixes," the tendency at the instant is to follow Brugmann's designation "Formantia" by adopting "formative elements." "Root determinatives" (a translation of Per Persson's "Wurzeldeterminativa") is a watchword in the linguistic camp. Instead of invariably postulating monosyllabic roots, as in our youth, the linguist nowadays often operates with "bases" that may be dissyllabic or trisyllabic. The importance, moreover, that is to be attached to the hypothetical reconstruction of primitive Indo-European forms like **ésti*, "he is," is open to more or less discussion, as referred to above and shown by the respective positions taken by Oertel and Buck at the philological session of the Congress of Arts and Sciences at St. Louis in 1904. In all such matters much depends upon the interpretation that we give to the hypothetical starred form—whether it be regarded as a convenient algebraic formula with which to operate, or whether we are to give more weight to it in presuming that it may represent a form actually spoken in some prehistoric period. It is likewise problematical how far the results obtained through linguistic evidence are to be used in reconstructing a picture of the conditions of primitive antiquity. Greater conservatism than formerly is used in this respect, and we are no longer so positive that the "daughter of the household" was the picturesque "milkmaid" in the dawn of Aryan civilization. Philological testimony serves rather as corroborative evidence than as a primary basis, and goes hand in hand with the evidence furnished by anthropology, geology, botany, and kindred sciences that help to elucidate the early history of man.

One topic more, before I close. Reference was made at the outset of this lecture to the universality of language.

But universality of language does not mean a universal language. From time to time the air has been charged with talk about *pasi-glots*, *pasi-linguas*, and *pasi-graphs*, which imply that the world is to have but a single speech. The notion is a millennial one and is as old as the days of the prophet Zoroaster if we may accept the authority of the *Bundahishn*, or "Book of Creation" (30. 23), and the Greek record of Plutarch, "Isis and Osiris" (47. 9). As long ago as 1668 a learned work on the subject of a theoretic and universal language was written by the Oxford divine, Bishop Wilkins, and entitled "An Essay towards a Real Character and a Philosophic Language"; since that time "universal languages" have appeared and disappeared without doing any serious good or serious harm. Volapük, Lange Bleu, Spelin, and Esperanto are but examples of the general movement that is really idealistic in its hopes. For those who care to read the latest word on the subject I would refer to Brugmann and Leskien's adverse article on the subject artificial languages in "*Indogermanische Forschungen*" (1907) and to Baudouin de Courtenay's rejoinder in "*Ostwalds Annalen der Naturphilosophie*" (1908), which represents the most favorable side of the matter.

And now to conclude—for I can not even mention a number of other problems—what has philology in its broadest sense accomplished?

It has brought cosmos out of chaos.

In its comparative aspect it has shown convincingly that a close kinship exists between groups of languages, and it has sought to classify these scientifically with appropriate reference to man's distribution throughout the world, though without insisting too strongly on the relation of language to race, for it fully recognizes the scientific importance of an adequately conservative view in that regard.

It has dealt liberally and sympathetically with the various aspects of language treated historically and philosophically as a factor in the world's civilization.

It has shown a praiseworthy readiness to ally itself with kindred sciences and often to adopt their results, even where its method of scholarly research had already lent much to them.

It has shown itself more than open to adopt into its service many new branches of study as forms of discipline if their activity be found suited to contribute to the ideal aim it has in view.

It has shown itself, on the other hand, more than intolerant of anything that approached charlatanism or was unworthy of science.

Last but not least, I would repeat again, the breadth and scope of philology in its broadest sense makes an appeal to the human heart and the human mind as a science, and I hope that you, my generous hearers, will graciously concede that the true philologist is not a man occupied with mere "words, words, words."

SYLLABUS OF THE LECTURE

Science of language and interest in linguistic studies, 5 — Breadth and scope of the subject, 6 — What is meant by 'Philology' and the terms 'Comparative Philology,' 'Science of Language,' 'Linguistics,' 6.

Language and its formation, 7 — Speculations with regard to the origin of language, and the interest taken in the philosophic side of language study, 7-8.

Historical sketch of researches in comparative philology, 9 — Early beginnings, 9 — The real foundation of the subject in the nineteenth century, 10 — The important part played by Sanskrit in the development of the science, 10 — Later researches and modern philological investigations, 12 — Linguistic phenomena and laws governing sound-change, 13 — Question as to the inviolability of linguistic laws, 13 — Formulation of various laws relating to consonantal and vocalic sound-changes, 14.

Physiological and psychological phases of language study, 16 — Phonetics as a special branch of linguistics, 16 — Some of the results of modern phonetic studies, 17 — Language and experimental psychology, 17 — Studies concerning disorders of language, 18 — Localization of language functions in the brain, and some of the relations between speech and thought, 18.

Dialect and language; the distribution of languages, and systems of classification, 19 — Great linguistic families, 19 — Growth of interest in the scientific study of the various language groups of the world, 20.

Relation of the science of language to other branches of scientific study, 22 — The comparative method applied to problems of grammatical structure, syntax, meter, and the like, 23 — Some present problems and tendencies in comparative philology, 24 — Estimate of what has been accomplished and outlook for the future, 28.

LITERATURE

**A LECTURE DELIVERED AT COLUMBIA UNIVERSITY
IN THE SERIES ON SCIENCE, PHILOSOPHY AND ART**

APRIL 8, 1908



LITERATURE

BY

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New York

THE COLUMBIA UNIVERSITY PRESS

1908

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Set up, and published May, 1908.

LITERATURE

LITERATURE is older than any of the sciences, as it is the foremost of all the arts. It is the expression in words of whatever man has done or felt or thought at any time since his inarticulate cries and incoherent stammerings were transmuted into language. Nor are we concerned alone with the written records, however formidable the mass of these may be. Recall the seemingly exhaustless temple-libraries of Assyria and Babylonia. Think of all that has been scratched on bricks and tiles, or graven upon cliffs, or painted upon tombs. Remember the epigraphical and paleographical remains of Greece and Rome and of the Middle Ages, the multitudinous papyri, the mountains of parchment, the smeared palimpsests, the wooden tablets, the inscribed potsherds, vases, what you please—writing, in fact, whether upon skins or clay or stone or bronze or lead. And think, as well, of the uncounted millions of printed pages that now convey the thoughts of men to men. When, in mind, we have marshalled all of this material, we shall then have noted only a part, and that the smaller part, of what we must in some way reckon with when we speak of literature.

For there is the literature which came into existence long before the art of writing,—literature which was transmitted orally from age to age or was forgotten almost in the making. The verbal reflex of action and thought and feeling is forever, in much the same fashion, still taking form

among peoples quite primitive and barbarous—Asiatic, African, and Polynesian—and the curious student may observe it to-day, just as he might have observed precisely the same thing ten thousand years ago. Therefore, what we usually call the whole body of the literature of mankind—meaning that to which we have ready access—is only a pitifully meagre fragment, after all. Literature irresistibly reminds one of the marvellous fecundity, the monstrous prodigality of Nature, which will spawn a hundred million life-germs and let them perish, in order that a single living organism may survive.

The immensity of the subject may well bewilder those who seek to reach any sort of generalisation with regard to it. Yet the very fact that our material for study is restricted to no one race or nation or time or stratum of civilization is in itself immensely significant. It reveals the presence of a universal instinct—an instinct which craves self-expression and the perpetuity of that self-expression. Literature is but a single manifestation of the will-to-live, the intensely human longing to be felt by others, to be really known by others, and, if possible, to be remembered by others.

So, amid all the woven words in many tongues, we can feel our way to a very broad definition of literature itself. We may call it an attempt at self-expression through language, due to at least a sub-conscious desire to perpetuate this self-expression. Such a definition is, as I have said, a very broad one. It is broad enough to include, on the one hand, the cadenced battle-yell of a horde of naked savages, or the measured ritual of a priestly sept or clan, and, on the other hand, it comprehends the delicate lace-like artistry of a lyric poet such as Horace or Hafiz.

Because literature is self-expression, and because the expression of self is always modified and coloured and variously controlled by a thousand subtle influences—geo-

graphical or racial or national or political or social—literature is an inexhaustible treasure-house whence every science may derive materials that are priceless. Here is a mass of evidence, of recorded experience, which bears upon all the problems of humanity in its slow progress up the heights. Without the literature of past ages the genetic study of any science is impossible. Indeed, whatever the mathematician, the metaphysician, the jurist, the biologist, the astronomer or the philosopher of to-day may choose to write concerning his own pursuit—that, too, is literature.

Literature is not itself a science. Yet is there possibly such a thing as a science of literature? Can the whole body of literature, in the largest sense, be studied by scientific methods in such a way as to yield exact and definite results? And what, we may ask, is the definition of a science? I think that Lamennais expressed it very well: "A science is a collection of thoughts and facts upon which all men are agreed." This definition rests upon the principle of common consent; that is, the common consent of "all men" who have studied and tested the thoughts and facts which have a direct and necessary relation to a particular science. No science stands still. New discoveries and more profound investigations, by eliciting a larger knowledge, will modify its laws. It is true, as Herder wrote to Reinhard, that "the last solved problem of this world and of mankind reveals immediately a new one to be solved." Yet the characteristic trait of an exact science is that, at any given time, its expositors are agreed upon the fundamentals, and that when a change occurs, it is a change accepted by them all.

Now, in this sense, is there as yet such a thing as a science of literature? If so, in what way did it come into existence? To search for ultimates, to consider all the influences and forces which by action and reaction, by relation and inter-relation, bring about any definite result, is always

difficult if not impossible. It will be perhaps sufficient here to consider only the immediate causes which have established what, if it be in reality a science, is the youngest of all sciences. To acquire an accurate perspective we need go no further back than the period of the French Revolution. That great cataclysm was accompanied and followed by an extraordinary intellectual ferment. Old truths were viewed with keenly searching eyes. Old falsehoods and outworn traditions came crashing down with the fabric of that feudalism which had cherished them so long. The spirit of inquiry, of challenge, of analysis, which is the spirit of science itself, was rife throughout the Western world. It resulted in the genesis of a scientific method of approaching literature,—a method blending various principles that are partly psychological, partly historical, and partly philosophical. There is much that must be here passed over; but the really formative forces may be summarised in the influence of four great formative personages.

Of these the first is the French novelist, Stendhal (or Henri Beyle). His works are really psychological demonstrations. Fiction, long regarded as an inferior branch, had, after the publication of Rousseau's "*Nouvelle Héloïse*," risen to the rank of serious literature, equal to tragedy itself as a vehicle of thought. With Stendhal in "*L'Amour*," and in his novels "*Armance*," "*La Chartreuse de Parme*," and "*Le Rouge et le Noir*," there is a meticulous analysis of thought and sentiment, often morbid yet always remarkably acute. He declared it to be his purpose "to make of fiction a mirror which, as you carry it through the streets, allows every kind of image to be reflected in it just as chance directs." This promised, at least, a degree of objectivity, but the promise was unfulfilled. His books are everywhere subjective, analytical. He cares nothing for environment, but only for individuals. Their most inti-

mate thoughts and feelings, as they flicker into consciousness and then die away, he notes,—holding his breath, as it were, in his anxiety not to lose the slightest quiver. It is an anxiety which he communicates to the reader. We feel in studying his pages what Zola has compared to the curiosity of a young child, holding a watch close to his ear and listening intently to its tickings. Here is a predominant psychology such as pure literature had not known before. Not long afterwards, in Michelet's "Histoire de France" (1838), there appears a new development of historical writing in which enormous erudition drawn from the dustiest of mediaeval records becomes under the magician's touch so vibrant, so palpitating, so alive with vivid imagery, and so rhythmic in its cadenced prose as to be at times quite truly lyrical. It combines the patient industry of the scholar with the glow and rush and animation of the poet. Every document, every record, every letter is made to yield at least some small detail of costume, features, manners, motive. Michelet showed just what intensity of life could be evoked by genius from the unsunned archives of a half-forgotten past.

Almost contemporaneously, Auguste Comte proclaimed his philosophy of Positivism. This was apparently unrelated to literature although destined to affect profoundly the development of literary methodology. The Positive Philosophy with its Law of the Three States—the theological, the metaphysical, and the positive—involved the application to social phenomena of scientific laws analogous to those which had been accepted in the study of chemistry, of physics, and of physiology. His theory of "social physics" looked to the coördination of the unquestioned facts of social life. The static law was the law of order. The dynamic law was the law of progress. In the last analysis all the facts of the social cosmos were to be viewed with reference to their mutual relations. "Not only," de-

clared Comte, "must political institutions and social manners and ideas be forever mutually connected; but more than this, the consolidated whole must be linked by its very nature with the corresponding state of humanity's integral development, viewed in all its aspects of intellectual and moral and physical activity."

Last of all (in 1862) came that brilliant, epoch-making generalisation of Herbert Spencer, Darwinian in its character, yet going far beyond Darwin's extension of a few types in the organic world. Spencer would explain the relations of all phenomena by combining the ideas of persistence of force, adjustment to environment, and the theory of natural selection. In other words, he would unify the cosmos, and make clear the myriad identities and relations which are found throughout the whole. The evolutionary theory relates not merely to the organic world but to the inorganic world as well,—to the sphere of ethics, politics, and social order. It is biology made universal, noting the relations and affinities, the processes of growth and of decay—"a continuous redistribution of matter and of motion." Thus, his formula applies to everything. - Spencer himself applied it to literary evolution.

The patient, laborious, and brilliant achievements of these four men—Stendhal, the writer of psychological fiction, Michelet, the master of historical imagination, and Comte and Spencer with their application of scientific laws to social life as well as to the world of mind,—may be taken as having laid a basis for the scientific study of literature. I have selected them as typical, being compelled to forego any consideration here of the great creative minds which, in other countries and in France itself, were gradually evolving a body of observations and hypotheses, all of which represent a single tendency. Thus, I must omit any account of the post-Kantian philosophers, Fichte and Hegel, Laas and Ziegler, and also that luminous critic,

August Wilhelm von Schlegel, whose "Vorlesungen" displayed the history of all literature as a process of social evolution. Nor can I do more than mention the Italians, Manzoni and De Sanctis, whose thought was so eminently fruitful. The four writers whom I have selected are those whose relation to the new science of literature can be immediately and clearly shown. They incarnate the spirit of their time. Each gave a definite impulse of which the effect was felt at once.

Already, while Stendhal was still writing, Sainte-Beuve had begun his finely discriminating literary studies wherein he applied to his own contemporaries—Chateaubriand, Victor Hugo, and others,—the same sort of subjective analytical methods which the novelist had devoted to the creatures of his imagination. Sainte-Beuve cared more about the personality of his subjects than about their works, or rather he believed that their works could be most clearly illuminated by the light of the writers' personality. He gathered every minute detail as to their ancestry, their lives, their habits, their peculiarities, their friendships and their hatreds, just as Michelet was doing with regard to the men and women of the past. And, like the historian's, his results are concrete, satisfying, life-like. Here is the psychology of Stendhal blended with the veracity and vividness of Michelet. Add to this the fact that, although his studies were based upon no conscious system, they show glimpses of the scientific *Schwärmerei* which was felt by all of his associates and which was in the very air he breathed. Even by his casual phrases he suggests it—the phrases which he uses to describe himself as "botanizing," as "dissecting," as "a natural historian of the mind," and as doing the work of an "anatomist" in literature. As he proceeded with his task, he evolved at least a partial theory of literary study, in recognizing the obligation of criticism to elucidate, to classify, and to attain a philosophic know-

ledge of the human intellect. But he admits, as well, that, in a masterpiece, no general principles can explain that elusive *aura* which is purely individual.

This last assertion was challenged, first in theory and finally in practice, by the most splendid historian of literature that France or any other country has given to the world. When Taine wrote his study of English literature, he did so in the spirit of the laboratory. From Stendhal he drew his experimental psychology. From Michelet he got his love for accumulating what he called "the little facts, well-chosen, full of meaning, amply verified, carefully noted." His passion for such facts as could be made to live and glow is shown in his opening pages where he bursts forth: "I would give fifty volumes of charters and a hundred volumes of state papers for the memoirs of Cellini, the epistles of Saint Paul, the table-talk of Luther, or the comedies of Aristophanes!" Like Michelet, he could mass his "little facts" and present them with a superb eloquence which Monod has styled "the gorgeous raiment of his logic." His rhetoric is, indeed, so brilliant that for the moment we do not perceive the coldness, the remorselessness of his science. Deriving from Hegel certain notions which he blends with the Comtian and Spencerian doctrines, he would explain all literary phenomena as due to race, environment, and "the moment," that is, the tendency to a definite evolution under given circumstances. Taine with his deterministic philosophy saw causes for everything. He saw causes for ambition and courage and truth, as well as for digestion, muscular movement, and animal heat. These are all products. "Virtue and vice are products, like vitriol and sugar." And so, too, a national literature is a product, like a honey-comb, and each work which composes it is a product, like each separate cell within the honey-comb,—the necessary result of some cause which the scientific mind can always bring to light.

Amiel once said of Taine's method that it "corroded," that it "gave algebra to those who asked for life." But to Taine more than to any other man is due the honour of having founded a would-be science of literature. Those who follow him merely modify his methods. Brunetière, for example, insists upon the element of individuality (also a borrowing from Hegel), and discusses biologically the evolution and differentiation of literary types. The Italian, Checchia, applies to literature all the Spencerian principles—natural selection, the struggle for existence, the survival of the fittest, atavism. In England, Posnett failed, though his failure was magnificent, in an attempt to trace the evolution of all literature, oriental and occidental as well, from its earliest and simplest forms to those that are the most complex, through the four stages of clan-literature, literature of the city commonwealth, world-literature, and national literature. It is impossible here to speak of the contributions to this subject which have come from Germany through the studies of Biedermann, Federn, Schmidt, Wolff, Groth, Scherer, and Goedecke; and from France through the writings of Pellissier, Joseph Texte, Hennequin, Letourneau, and Ricardou. Nor can I consider here the work of the Spaniard, Menendez, the Italian, Spera, the Danish scholar, Brandes, nor that of our own countrymen such as Professors Gummere and Gayley.

And thus, there came into being a science of literature, or if you prefer, a mode of literary study which aspires to become a science. I dislike to use the term "Comparative Literature." If I do so, it is simply for convenience. The name is almost meaningless, or at any rate, it does not mean what it was meant to mean. It is not a translation of the French *littérature comparée*. When we speak of "Comparative Literature," we are really to understand the comparative study of literature, or better still, the study of literary evolution. In its strictest, straitest sense, it is a

science which seeks to establish certain general facts regarding the whole body of literary expression as noted in all countries and in all times; to detect amid this complex maze the presence of some guiding principle, some controlling law. Its methods are theoretically those of the comparative anatomist or the comparative philologist. Like any science, it begins with the accumulation of facts, and it would employ a dispassionate, unbiased criticism in the sifting and interpretation of these facts.

To be more concrete, I will mention a few of the problems which confront the investigator in this field. For instance, in what manner does the evolution of literature first take place? Can literature be shown to have a definite relation to the growth of religious, political, and social institutions? To what extent does environment, in the broadest sense of the term, affect the character and growth of literature? Are literary "movements," from the time of their origin down to the period of their decline, due to the operation of any general laws? Or, to suggest other questions collateral to these, is there any one primitive form of self-expression through language, from which all the other forms of self-expression are derived? Does poetry in its historical evolution precede prose, or does prose precede poetry, or are they of simultaneous origin? Is one form of literature developed out of another,—as for instance, the epic from the lyric, the drama from a combination of the lyric and the epic, and prose fiction from the lyric, the epic, and the drama? How has one literary "movement" reacted upon another? How has the thought of one nation, as embodied in its literature, coloured and helped to mould the literature of another nation? Why is the Teutonic spirit essentially lyrical? Why does the genius of the French turn almost instinctively to a certain ordered *ἐπιείκεια* which willingly accepts control and takes on that character of fixity which the Buddhist declares to be

"the true sign of the law"? Dr. Butler lately said with perfect truth: "The deepest cleavage known to history is that between the Orient and the Occident,"—a thought which is embodied in a well-known refrain of Kipling's. This cleavage is a great abyss which has never yet been spanned either in philosophy or in philology. Can the student of Comparative Literature bridge it over and account for the antipodal, the almost antipathetic, difference between the spirit of the East and the spirit of the West?

Merely to propound these questions is to show how very difficult must be the answer to them,—at least an answer that shall satisfy the definition which I have already quoted from Lamennais. Some enthusiasts are willing to see a parallel between Comparative Anatomy and Comparative Literature. But to assume such a parallel is, of course, misleading. Comparative Anatomy has to do only with material objects. Comparative Literature, on the other hand, cannot exclude the hidden forces and immaterial essences which pervade all self-expression, through the subtle, iridescent medium of language, with its delicate shading, its *nuances*, its impalpable reflection of man's inner mind, its innumerable variations due to race, tradition, and environment. For example, let us suppose that the skeleton of a pre-historic elk is viewed and independently described, first by an American anatomist, then by a German, a Russian, an Italian, a Frenchman, and an Englishman, and that these several reports are placed in the hands of a Japanese anatomist who has never seen the skeleton. The Japanese anatomist will get as clear a comprehension of the object as though he had himself beheld it. He will know that it used to be an elk. The reports given him will all agree. But let a lyric poem or a dramatic trilogy or a literary *genre* be examined and independently described by an American, a German, a Russian, an Italian, a

Frenchman, and an Englishman, and what sort of an impression will be made upon a Japanese by the study of their several opinions? It will be very much as though, in the other case, the skeleton of the elk had been described, first by a person of fairly normal vision, then by one afflicted with ophthalmia, by another who was strabismic, by another who was astigmatic, by another who was colour-blind, and by still another who was amblyopic almost to the point of caecitude. Put their reports together and give them to an unsuspecting and indifferent person. What impression will he receive from them? Most likely it will never occur to him that these individuals are all describing exactly the same skeleton. If it should occur to him, then what sort of animal will he assume the creature to have been? He might imagine that perhaps it was once a cow, or he might imagine that perhaps it was once a crocodile.

There is very much the same diversity of view among students of Comparative Literature in the present state of its development. Take, for example, the theory of origins. One investigator will hold, with Steinthal and Posnett, that literature was communal in the beginning, expressing the common feeling of a sept. Another, like Scherer, will say that literature was at first absolutely individual self-expression. One theorist sees somewhere in the remote past "a dancing, singing, improvising multitude." Another skeptically asks whether there can be such a thing as simultaneous, spontaneous composition. How did poetry begin? Songs were first invented, says one, to lighten labour. No, says another, they were merely mnemonic devices to aid the memory. Not at all, remarks a third; songs were a concomitant of the primitive dance, a vocal expression of the "play instinct," seeking naturally after rhythmic movement. So the Arabs tell us that Khalil's rhythms came to him from hearing the cadenced hammering of the

workmen at the forge, and that the traditional *hidâ*, or song of the camel-driver, was inspired by the steady lurching motion of the camel, whose master unconsciously imitated its sway and swing in the pulsations of a definite metre. Yet against this view Kawczynski tries to show that neither dance nor song was spontaneously natural, but instead wholly artificial, the invention of some ingenious anthropoid, half-man, half-ape; while again, Schneider and others would look on poetry as having been originally a branch of medicine. Who is agreed, even upon a definition of poetry itself? Shall we say with Aristotle that it springs from imitation and the sense of rhythm, or with Carlyle that it is "musical thought," or with Wordsworth that it is "the breath and finer spirit of all knowledge," or with Mill that it is "the thought and words in which emotion is spontaneously embodied," or with Emerson that it is "the piety of intellect—a presence of mind that gives a miraculous command of all means of uttering the thought and feeling of the moment"; or with Schopenhauer that it is "the supreme objectification of the idea of man"? Or, bewildered by innumerable definitions which do not define or which confuse the poetic gift with the poetic work itself, shall we become Philistines and, turning with a reprehensible feeling of relief to a great mathematician, shall we accept Sir Isaac Newton's dictum, so delightful in its simplicity, that "poetry is ingenious fiddle-faddle"?

Evidently, where no one is agreed even upon fundamental definitions, a science is as yet not so very scientific. Herr Wilhelm Wetz, an ardent follower of Taine, stoutly asserts that a science of literature is possible, and that in the end it will rival the exact sciences in the precision of its results as well as in the thoroughness of its methods. At the present time, however, we must regard Comparative Literature as being really in its infancy, standing where Comparative Philology stood in the years after Franz

Bopp had published his "Vergleichende Grammatik," and before Verner and Brugmann had reached those epoch-making discoveries which brought order out of chaos. There are, no doubt, relations and principles and laws in literature just as there are relations and principles and laws in astronomy and botany. But it will be a long while, I fear, before the relations and principles and laws of literature are ascertained and generally accepted as representing valid truths. More facts must be accumulated and new hypotheses must be framed, even though the facts are still defective, and even though the hypotheses are still erroneous. "The historical progress of every science," says Huxley, "depends upon the criticism of hypotheses, upon the stripping off, that is, of the untrue or superficial parts, until there remains only that exact verbal expression of as much as we know of the fact and no more, which constitutes a perfect scientific theory." The most original of American philosophers once remarked: "Generalisation is always a new influx of the divinity into the mind." It may be that, at some time or other, Comparative Literature may give the world a new influx of divinity by some truly scientific generalisation. But to-day if it be a science at all, it is a very inexact and empirical science, comparable perhaps, at the most, with medicine. Those who pursue it must remain content with contributing many facts of value in the interpretation and appreciation of literature itself.

The conscientious student of Comparative Literature will interest himself in every form of literary expression. He will find food for thought in the Mahābhārata, and he will find it also in a penny-dreadful. He can learn impartially from the sayings of Confucius or from the fables of Mr. George Ade. But there is a narrower definition of literature which will exclude a great deal of what many are fond of reading. This narrower definition has to do with literature as a fine art; and literature as a fine art

means self-expression conveyed through language in such a way as to afford an enduring aesthetic pleasure. The distinction between the fine or "liberal" arts and the useful arts was first made plain by Aristotle some twenty-two centuries ago. It was not a distinction which the Greeks had observed before him, but it is a distinction which has been accepted ever since. The useful and the beautiful had hitherto been blended. Perhaps it is unfortunate that they have now become so clearly differentiated. But in literature the difference was actually there, and Aristotle simply recognised its presence.

Now it is not so very hard to make a definition. The actual difficulty arises in the application of it. Walter Pater once divided literature into "great" literature and "good" literature. This division is convenient. There are some works of genius which everyone would classify as belonging to the category of great literature. There are many other works of which any intelligent person would say that they are neither great nor good. But there is also a literary borderland wherein opinions differ; and no one who is quite honest can say of certain books or other works of literary art in just what category they are rightly to be placed. I am reminded here of Horace who in one of his Satires raises the question whether the sort of verse that he is writing is really poetry at all; and he remarks that he will discuss this question at another time. But Horace was a very sagacious person, and he took good care that the other time should never come. This same wisdom would befit all of us when we are tempted to be dogmatic on the lower levels of literary criticism. It is safer and much more profitable to look, as Aristotle did, only at those supreme creations, true to life and nature, which have withstood the test of time.

Aristotle, writing at the beginning of Greek decadence, tried in his "Poetics" to determine from the study of the

greatest works, what laws had influenced their composition, and to set forth the principles of literature and the fine arts. Of course, his sphere of observation was comparatively limited. The drama, the epic, and history were the forms which he most carefully considered. But, within this sphere, he dealt with masterpieces only, and his mind was not confused by a multitude of varying types. What has always struck me most in reading the "Poetics" is the simplicity and largeness and wisdom of his fundamental teachings. It is because of their simplicity and sanity that they have kept an unshaken hold upon the minds of men, all over the Western world, down to our own time. Aristotle knew there must be a certain liberality, a certain largeness—to some extent even a certain vagueness—in any good generalisation. He knew that no artist should be absolutely fettered by a formula. Thus, he frankly refrains from drawing any very clear distinction between poetry and prose, based upon a difference of external form. The history of Herodotus would still have been a history even had it been composed in metre. Presumably the converse of this proposition is implied; and the Homeric epics would have been epic poetry even had they not complied with metric form. It is unnecessary, indeed, that poetry should take any given form or be cast in any given mould, or even that it should have rhythm, and recurring cadences, and perceptible felicities of sound. Thus is Walt Whitman justified by Aristotle. Thus, too, are we justified when we maintain that some of the finest lyrics and some of the most beautiful examples of narrative and meditative poetry in modern literature are to be found in what, conventionally, we describe as prose. We may rightly apply the name "lyric" to certain famous passages in Victor Hugo's novels, such as his "*Travailleurs de la Mer*," which were written at white heat. We may rightly apply the name "epic" to some of the overwhelming chapters in Émile Zola's "*La*

Débâcle" or in Tolstoy's "War and Peace." The flashing, flaming rhapsodies of Nietzsche are truly dithyrambic poetry. Some of Matthew Arnold's exquisitely wrought passages—his memorable characterisation of Shelley, for example, and his impression of the towers and gardens of Oxford by moonlight—are very beautiful contemplative poetry.

There is the same largeness of grasp in Aristotle's description of the artistic "Imitation of Nature." "The artist," he remarks, "imitates nature." But it is plain from comparing different passages in Aristotle that it is not a process of slavish copying, but rather one of independent creation which makes the artist a rival even of Nature itself. The artist imitates Nature in that he works upon materials just as Nature does; but out of his materials, which are ideas and experiences, he constructs a real world of which he is himself the demiurge. He will then set before us something, not as it is in its own essence, but as it appears to the human mind and senses. This may be illustrated in the graphic arts by an anecdote often told of Turner. Turner had painted a view of Portsmouth Harbour with its shipping as seen from a considerable distance. An old sea-captain, after carefully scrutinising the painting, said to Turner bluntly: "Your picture is all wrong. You have n't painted any portholes on that man-of-war." "Of course not," answered Turner; "because at such a distance no one could see the portholes." Here is where art is at variance with science. A cavalry charge, as painted by Meissonier, shows us the horses precisely as our senses show them to us. The legs curve as the animals plunge forward, and every line is a line of beauty. Instantaneous photography, however, reveals the fact that, during each fraction of a second of the time in which we view a galloping horse, its limbs never take the position in which we think we see them. They are really disposed most awk-

wardly and even fantastically. The artist's guide in painting them is the human eye and not the sensitive plate of a camera. As Ruskin said in substance, it is the function of art to represent what is visible, and not to give a scientific explanation of what composes anything, or of what may be inside it and invisible, far less just how it came about.

So again, Aristotle finds an intimate connection between all of the fine arts. Dancing, poetry, music, painting, and sculpture, have a common bond in rhythm—not the rhythm which is expressed in sound, but that subtle symmetry which springs from balance and proportion, whether these be recognised in shape and line and colour, or whether in movement, or in the harmony of the parts that enter into the verses of a great poet or the periods of a great prose writer. But after him came other critics who insisted upon a formal regularity of definition and who strove to blot out any ultimate distinction between the plastic and the graphic arts, and poetry. The famous phrase of Horace in his “*Ars Poetica*”—*ut pictura poësis*—became a text from which to preach the doctrine that there is no distinction whatsoever between the scope and function of poetry and the scope and function of painting and sculpture. This narrowing of the Aristotelian teaching was accepted until after the middle of the eighteenth century. Everyone is familiar with the clear interpretation which Lessing gave in his “*Laocoön*”—an interpretation which set this subject once for all in its proper light.

Lessing, with a profound insight into ultimates, showed that poetry has to do with action, while the plastic arts and painting have to do with situations. Sculpture, for example, must suggest motion by bodily forms. Poetry, on the other hand, must suggest bodily forms by actions. Painting and sculpture, while they may suggest ideas, can do so only through the associations of sight. They can, indeed, depict movement and action, but this representation is

limited to a single moment of time. Hence, the range of poetry is wider, and it gives to the invention far greater play. Sculpture and painting, since they are static and of the essence of fixity, must confine themselves to the beautiful; while poetry, and, indeed, all literature, in revealing the entire moral world, may include the ugly and the horrible as incarnating the evil which is found within the moral world. The fixity of painting and of sculpture imposes a perpetual limitation. To give enduring pleasure, these must confine themselves to the serene, the majestic, the beautiful, and the sublime. The laws of sculptural beauty do not allow the presentation of faces distorted by hatred, or by anger, or by any violent emotion. Sculpture must not show us contorted limbs or writhing bodies. It may suggest motion, but it must not directly represent it. As Professor Kuno Francke has well said: "A waterfall represented in marble ceases to be a waterfall and becomes a block of ice; a fleeting smile, arrested on canvas, ceases to be a smile and becomes a grin."

Literature, however, which appeals to us through language, shakes itself free from the fetters of time and space, and gives us action, movement, continuity, as none of the other arts can do. It is perhaps rather trite to quote here, as a perfect expression of this truth, a few lines from that famous ode of Keats, professedly inspired by the sculptured figures on a Grecian urn. An ardent youth approaches a graceful girl who gladly waits his coming. But in sculpture they can never meet. Their love remains without its consummation.

*"Fair youth, beneath the trees, thou canst not leave
Thy song, nor ever can those trees be bare;
Bold lover, never, never canst thou kiss,
Though winning near the goal—yet, do not grieve;
She cannot fade, though thou hast not thy bliss,
For ever wilt thou love, and she be fair!"

After Lessing had published his "Laocoön," Goethe wrote of it: "One must be young to conceive what an influence it had on us in taking us from the realm of dreary contemplation to the free fields of thought. The distinction of the speaking and the plastic arts was clear. All the consequences of this glorious thought were revealed to us by a flash of lightning." At present there is a disposition to belittle Lessing's insight which restored the true supremacy of Aristotle. The distinction which he made is now so obvious as to be sneered at as a truism. A sneer like this is most ungrateful as well as rather stupid. Every genuine truth in time becomes a truism. Indeed, a genuine truth can be found nowhere save in truisms or perhaps in paradoxes; for, after all, a paradox is nothing but a truism which looks as though it had gone wrong.

I have touched upon one or two of the Aristotelian teachings as to literature, simply to illustrate the marvelous influence which he has exerted on succeeding ages. He has often been misinterpreted. He has sometimes been attacked as critically unsound. But never has he been ignored. The subtlety and vitality of his wonderful mind have lost nothing of their power through all the centuries. There have been many periods of literary criticism since his time—the Alexandro-Roman period with its would-be cosmopolitanism, the Mediaeval period with its symbolism, the period of the Renaissance when the true Aristotelian doctrine of the imitation of nature returned, only to be shrivelled into pseudo-classicism, and the period which followed the French Revolution;—yet never has the Western world shaken off the Aristotelian influence. From Plotinus and Longinus and Cicero and Horace and Plutarch, to Castelvetro and Corneille and Lessing and even Taine, nearly all discussions of the deeper problems of literature begin with the "Poetics" of Aristotle.

The most profound of all his doctrines is that which has

to do with the Universal. The imitation of Nature of which he speaks must be an imitation of that in Nature which is universal. In literature, this means that the artist will not appeal, in what he writes, to the mood, or the emotion, or the prejudice of a limited group of human beings, even though that group be a nation or a race. It will not suggest what belongs only to a particular moment, a particular period, or to a particular individual, as an individual. He must, instead, somehow infuse into his work that feeling which is elemental and which is common to all mankind beneath the superficial differences of time and place and nationality. He must reject the ephemeral and the irrelevant in accordance with the saying of Michelangelo who defined art as "the purgation of superfluities." Only in this way can he give enduring life to what he writes. Lately this doctrine has been challenged. It has been said that, in the development of the human race, with all the differences of language, of social, religious, and political institutions, no universal element remains. Can this be really true? Upon the answer to the question many things depend. Unless there is something in the emotional nature of man that is as changeless as the persistence of force, then there can be no such thing as permanence in literature. The great works of classical antiquity will ultimately perish. The great classics of modern times will follow them down into the pit. Nowhere in this whole spacious field of man's creativeness will there be stability, but only unending change and ultimate decay.

Let us consider whether the doctrine of the Universal rests on reasonable grounds. There surely is a universal element in man's nature. The difficulty arises when you ask whether anyone, however great his sympathy, his insight, and his mastery of literary art, can seize and fix forever in literature an expression of universality so as to make his masterpiece one to be understood by human be-

ings everywhere and throughout all time. None will deny the existence of emotions which are elemental and also universal. Hate, fear, love, the instinct of self-preservation, reverence for something that is above us or beyond us, and also that quality which is expressed most surely by the Latin word *virtus*—all these affect the actions of men and women everywhere. The most primitive utterance of them through sound, just one degree below the point at which articulate language begins, is universally intelligible. A shout of triumph, a yell of hate, a scream of fear, a moan of pain, a cry of passion,—the meaning of these is obvious at once to the rudest savage and to the most highly cultivated European. But while the emotions, as emotions, universally exist, they are by no means manifested in the same way or excited by the same causes. For example, let us believe the poet who says

“The truth of truths is love.”

Yet the objects to which love goes out and those to which it does not go out, are very different in different ages and among different peoples. In Greece and Rome it did not go out to the helpless child exposed by its parents at birth. With us it is not excited, as it is in the Chinese, by the remembrance of our distant ancestors. In many lands it is not given to the wife. Again, with us there is a love of country, often greater and more intense than love of life, or even than the love of those who are very dear to us. Yet to a Chinese a sentiment such as this is unintelligible. Few Chinese serve their country just because it is their country. Confucius himself, in a sentence recorded in his “Analects,” declared: “He who is not in office has no interest in his country’s government.” And so when literature tries to give expression to any of the elemental emotions it may make a strong appeal to one race, with whose traditions it

accords, while it may seem strange and even monstrous to the people of another race. Even an educated and Anglicised Hindu could not read without repulsion Thackeray's novel "Vanity Fair," with its story of the long devotion of Dobbin for the widow of his dead friend, Osborne. The Hindu simply would not understand it; for, according to his view, Amelia should have been burned alive at the death of her first husband. To take a more striking instance, let us consider whether Shakespeare is as truly universal as the English-speaking peoples think he is. Almost all concede that "Hamlet" is the finest of his plays, the one in which his genius finds its subtlest and most powerful expression. Yet we remember how Voltaire (in the introduction to "Semiramis") asserted that the play reminded him of "the work of a drunken savage." This we might set down to national prejudice. But let us turn from the Frenchman with his pseudo-classical tradition, and get the opinion of one who is in every respect the antithesis of Voltaire—the Russian, Tolstoy. He once remarked: "This play of Shakespeare afflicts me with that peculiar *malaise* which meretricious works produce." It is "calculated and unspontaneous." It is "coarse and often senseless." If we turn again, even to an Englishman, to a countryman of Shakespeare, to John Ruskin, we read in his "Praeterita" these words: "Why must every happy scene in the loveliest plays be all mixed and encumbered with languid and common work?"

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Again, a Spencerian such as Professor Posnett picks to pieces certain of the Shakespearian dramas for the same purpose,—to show that their author is not universal in his conception of character, "any more than in his conception of plants or animals or scenery." Mr. Posnett asserts that Shakespeare's Romans, for example, are not historical Romans. They are not even pagans. His women—Portia, Calphurnia, Volumnia, Virgilia, "are really Chris-

tian women married by Christian marriage," and knowing the relations of family life which are familiar to modern and Christian times. The Roman men in Shakespeare's plays are in reality men of Elizabethan London, when they are not mediaeval knights. So, too, of the Shakespearian anachronisms, such as the cannon at the siege of Troy, and the town-clocks striking in the Rome of Julius Caesar. Hence, it is argued that we are not to look for universality in even the greatest poets, of whom Shakespeare may be taken as a type.

To my mind the defect in all this reasoning is a defect which shows the Aristotelian influence again. Aristotle thought the drama, or, in other words, tragedy, to be the highest form of literary art; and, perhaps unconsciously, Professor Posnett has accepted this view in trying to refute the doctrine of the Universal. But in fact, the drama—that is to say the acted drama—is only in part a form of literature. It is something more than literature, for it is literature blended with all the other arts. The dance, the song, the painter's colouring, and music, too, are there, and the effect of animated sculpture is found in the living men and women who impersonate the characters. This remarkable *mélange* of the arts does, to be sure, make the drama overwhelming in its immediate effect; but it also forces the dramatist to be something more or less than a literary artist. The accessories which aid him to melt his audience to tears or rouse them to mirth or inflame them to a pitch of passionate intensity overcloud the drama as pure literature. They tend to confine the general action and also the conception of character to a particular time or country; and therefore, when, centuries later, we read the plays, stripped of their accessories, we have a feeling of remoteness, so that the purely theatric defects of the artist stand out glaringly and we mock at his anachronisms. The really universal element in

the drama, therefore, I take to be those passages which are the least dramatic. It must have been such passages which Ruskin had in mind when he spoke of the "happy scenes" and "loveliness" of Shakespeare's plays; and doubtless he recalled only the ephemeral element when he spoke of the "languid, common work." Voltaire would never have styled Shakespeare "a drunken savage" had he read in "Hamlet" only the fine soliloquies and philosophic lines, and had his attention not been distracted by the stabbings, murders, and sudden deaths which to-day, even among men of Shakespeare's race, make the judicious grieve.

I believe, therefore, that the universal element is most clearly felt in the literature which comes nearest to the primitive form of self-expression,—that is to say, the lyric, where the individual soul floats, as it were, above the limitations of time and space and all convention, and displays itself in something of its elemental nakedness. And here we must consider the two modes which are styled respectively Classicism and Romanticism. Many critics, influenced by Comte, perceive three modes in literature, corresponding with Comte's Three States. It is a bit of classification which pleases those who are fond of symmetrical formulas and who perhaps inherit an atavistic reverence for the once mystic number three. Thus, as Comte gives us the theological state, the metaphysical state, and the positive state, so these Comtian critics speak of the ancient mode, the mediaeval mode, and the modern mode, or, let us say, Classicism, Symbolism, and Romanticism. This is very pretty as a piece of classification, but in reality we may eliminate Symbolism, since it is partly frozen Classicism and partly weak Romanticism.

Mr. Lecky has well said that every human being is born either a Stoic or an Epicurean. One might also say that every human being is born with a temperamental tendency either to Classicism or to Romanticism. And these terms

must be used with technical exactness. In reading many of our histories of literature, one might fancy that Romanticism was essentially a modern thing, which sprang up in Germany, and France, and England in the eighteenth and nineteenth centuries. In truth, however, Romanticism is no more essentially modern than Classicism is essentially ancient. Modern times have developed nothing new in the modes of literary expression or, for that matter, in literary forms. Thus, Montaigne is not really the father of the essay, for we find the essay written most delightfully by Horace and Seneca and Plutarch. The realistic and even the naturalistic novel of Zola and his imitators is as ancient as Petronius. The psychico-physiological novel can be traced to the "Daphnis and Chloë" of the pseudo-Longus. The historical romance is as old as Xenophon. The novel told in letters comes to us from Alciphron of Athens. The same thing is true in poetry as well. The melodrama, in whatever modern language, has its ancestor in Seneca's "Medea," where the scorned and insulted wife goes mad upon the stage and, rolling her bloodshot eyes, plunges a dagger into the hearts of her own children. For the prototype of the enervated *décadent*—the self-pitying, effeminate, neurotic youth, an Alfred de Musset or a Baudelaire—we can go back as far, at least, as the Roman Propertius, with his genius and his degeneracy. There is nothing new in literature to-day and probably there never has been for the last forty centuries.

And so Romanticism is not especially a new thing any more than Classicism is especially an ancient thing. Both of them really represent opposing phases of temperament. Classicism means self-repression, impersonality, detachment in the artist, displaying universal truths and feelings, but doing it in such a way that those who read take no thought of the author but only of the author's work. In Classicism one finds lofty, calm conceptions, and an appre-

ciation of what is subtle, delicate, and varied. Classicism does not deal with mystery and pathos or momentary passion or eccentric character. It portrays things with simplicity and it has the temperament of equity, serenity, *σπουδαιότης* and freedom from all self-assertion. This was not peculiar to the Greeks, for the Greeks share it with many moderns. Romanticism, on the other hand, as Brunetière has very clearly pointed out, is intensely individualistic. It involves "artistic egoism, since the emotions of a writer are effectively employed only when they re-echo and intensify the emotions which are our own." So Goethe expressed the Romantic creed in a Kantian manner when he wrote: "As man must live from within outward, so the artist must work from within outward, understanding that, no matter what contortions he may make, he can only bring to light his own individuality. . . . In this way alone is it possible to be original." And again, when the great German was asked to rouse his countrymen against the French invaders at the time of the Napoleonic wars, he said to Eckermann: "I have composed love-songs only when I loved. Can I possibly write songs of hate without really hating?"

Classicism was not predominant even in the most classic period of Greek antiquity. By common consent, Sophocles is the incarnation of the classic spirit, lofty, noble, free from passion, purged of superfluities. But his great contemporary, Euripides, was essentially romantic. Dr. Verrall has acutely said: "As truly as a song is written to be sung, the plays of Euripides were written to be talked about." Men came away from the "Oedipus" of Sophocles, awed and moved by the grandeur and the almost religious solemnity of what they had just seen. They came away from the "Alcestis" of Euripides chattering volubly of what the "master" meant, and they were puzzled by his ingenuities as men to-day are puzzled by the ingenuities

of Ibsen. Dramatically, indeed, Euripides is a remote ancestor of George Bernard Shaw. Philosophically, his indeterminism, his indifferentism, his belief that chance controls the destinies of men, make him a remote ancestor of Professor William James. Vergil was in part Classicist and in part Romanticist. Throughout most of the "Aeneid" he is classic, but in the Fourth Book he is a Romantic of the Romantics with his poignant portrayal of a woman's tenderness and passionate self-abandonment. Nor does Romanticism have to do with the beautiful alone. Nietzsche once wrote: "The idealist is incorrigible. If cast down from heaven, he makes an ideal out of hell." It is so with the Romanticist. When Juliet is wooed by Romeo in the moonlit beauty of an Italian garden, with the soft wind murmuring in the trees and the notes of the nightingale fluting amid the words of love, Shakespeare is a Romantic. But when in "L'Assommoir," Gervaise, the washerwoman, is wooed by Coupeau, the tinsmith, in a squalid *entresol*, on a stifling night, by the flare of a guttering tallow candle amid the ascending effluvia of an open sewer, while the maudlin sobs of a drunkard in the street below are heard from time to time, then Zola is a Romantic too. It is nearly the reverse of the same shield.

There is no other true division of the works of literature. A realist may be Romantic or he may be Classic, and so may a symbolist, a naturalist or a sensitivist. It all depends on whether he forces his own personality upon you, or whether he lets the action arise as of necessity. Thus, Milton is a Classicist, and Tennyson a Romanticist. Flaubert is a Classicist, while Zola is nearly always a Romanticist. George Eliot is a Classicist, while Thackeray is a Romanticist. In any case, the law of the Universal holds; and the Universal is clearly seen in the particular, wherever literature has created a semblance of organic nature, a true illusion in the world of our ideas.

Classicism, by its conformity to a certain order and decorum, tends to harden into an artistic mechanism. Romanticism, because it obeys no law, is apt to degenerate into pathological grotesqueness. Then we have, on the one hand, a pseudo-classicism, and on the other hand a pseudo-romanticism. The pseudo-classic writer is dull because he is the slave of classic formulas. The pseudo-romanticist is dull because he shows us the isolated individual, not as a universal type, but as an eccentric pervert, with whom most of us have nought in common. We see our own selves reflected in the diary of Samuel Pepys, or in the autobiography of Benjamin Franklin, in Defoe's realism or even in the irresponsible memoirs of Casanova; but we turn away from such a writer as the German, Barthold Heinrich Brockes, when in his poetry he thanks God for having blessed him during his sixty-five years of life with 46,700 meals, and 23,360 comfortable nights. This is the individual who is typical of nothing, who has no meaning for us. Who cares how many meals Brockes consumed or how many nights he slept in comfort? In Defoe and Franklin the Universal is discernible in the individual; in Brockes there is seen only the stall-fed egoist who, in the terse phrase of Rivarol, "writes for us with opium on a sheet of lead."

The art of literature is an art which affords enduring aesthetic pleasure. But some have asked the question "To whom should it afford the pleasure?" To the artist himself? Or to the rest of us? Are we to hold that the artist is independent of the world, that he should live in a *tour d'ivoire*, devoted wholly to his technique, and feeling for his potential readers that touch of condescension which the lawyer and the physician exhibit to the layman? This is the creed of Art for Art's Sake, and it is opposed to the primary conception of literature which makes it something which desires to endure. Yet it can endure only when the

artist is in full accord with the intangible yet powerful influences which surround him. Literature is a social thing; and this, at least, the comparative study of literature has plainly shown. The more sensitive, the more alive the artist is to the meaning of his work, the more surely he responds to the insistent pressure of the whole great world without. The noblest creative minds in all the past are those of men who lived with other men and who wrought out their masterpieces amid the rush of human life. Aeschylus the soldier and official, Sophocles the general and commander of a fleet, Aristophanes, Euripides, all of them contending for dramatic prizes, Pindar and Simonides the court poets, Dante the ardent patriot, Shakespeare the busy man of practical affairs, Cervantes the naval commissary and tax-collector,—can we imagine any of these men as isolated from active life, or as closely studying the niceties of mere technique? Mr. Howells has very finely said: "Supreme art in literature has its highest effect in making men set art forever below humanity."

There is an ethical aspect to this question which is always coming into view and troubling many honest souls. If the literary artist considers art alone, morality is quite clearly no concern of his. If, on the other hand, mere pleasure for his readers is the aim of literature, this seems a no less dangerous doctrine. Here is apparently a serious dilemma. Aristotle everywhere implies that the artist has nothing to do with instruction. His duty is not to teach but simply to give pleasure. This was also the conclusion reached long afterward by Kant and those who thought with him. Yet many have tried to evade the logic of this reasoning. Brunetière, who believes that literature tends toward the perfection of social life, rather feebly says that it will always be moral "to the exact extent to which morality is indispensable." Posnett, even, shrinks from admitting frankly that art has no immediate connection with moral-

ity. He figures someone as saying that his view of literature "cuts at the roots of moral conduct," and he exclaims "Far from it!" Yet he gives no reason for his indignant answer. Indeed, all who think that pleasure is the aim of literature are very mealy-mouthed in speaking of its moral aspect. And why? Because they all approach it from the wrong direction. Pleasure is, in truth, the only guide which literature must follow. The literary artist may be unmoral or immoral if he pleases. He is free to pander to the base. He is free to prostitute his art. But if he does so, then he does it at his peril. And this peril is a peril to the one thing for which every true artist cares the most—his lasting reputation, his enduring fame. For the healthy human mind is no more gratified by what is low and vile in art, than is the healthy human body willing to be nourished from a garbage-heap. Of all the masterpieces which have stood the test of time, which men and women read and love, there is not one whose spirit is unethical. In Dr. Johnson's homely phrase, every one of them has salt enough to keep it sweet. And this is why the doctrine of aesthetic pleasure has no danger in it. Art is defended against itself by the innate cleanness and rightness of the human mind, and not by any law of logic or of criticism.

And what shall we hold to be the function of literary criticism? I say the "function" and not the "object," for the object of each school of criticism may be wholly different from that of all the rest. Some persons look on criticism with mistrust, because they say that criticism kills creation. The history of literature does not justify this view. In Greece and England, for example, creation preceded criticism. In Germany, criticism preceded creation; for, as Mr. Saintsbury has cleverly expressed it: "The whole of German literature from 1750 to 1830 was a sort of seminar." In France, creation and criticism have gone hand in hand together through the centuries. What, then,

is the true function of literary criticism? Everyone remembers Matthew Arnold's ingenious exposition of it: that criticism prepares the materials, that is to say, the ideas, upon which the creative power works. Criticism analyses and discusses, while the highest order of literary genius synthesises and creates. But to-day, criticism—or rather the critics—have grown more arrogant. Thus, Posnett bluntly says that criticism is superior to creation, and that “the glimmerings of human divinity are visible” not in the artist's work but “in the reflection of the critic.” M. Anatole France goes even further, and declares that criticism is the “ultimate evolution of literature—the last in date of all literary forms and destined in the end to absorb all others.”

Sic vos non vobis! one is tempted to exclaim. So a lovely landscape, rich with the deep greenery of groves, and meadows flecked with the star-fire and gold of flowers are intended for whom? For you? For me? No; for the botanist alone. Man is born—why? That he may live and love and play his part in the world of thought and action? No. He is born only that his body may be dissected by the physiologist after death! And literature, that has risen like a radiant mist from every land and every race for centuries, was brought into being solely for the critic! The joys of uncounted millions have given it their gladness for its own. Some of its noblest pages have been written by men and women who dipped their pens in their own blood and tears—and all that criticism might at some time condescend to study it! Better than this would be the state of things which Landor noted when he said of his fellow countrymen: “We admire by tradition and we criticise by caprice.”

No; the true function of literary criticism is the modest one which Sainte-Beuve assigned to it as “the secretary of the public.” Criticism is “an emanation of books,” and its true function is neither to create nor greatly to assist crea-

tion. Whether it be good or bad, whether you call it objective or subjective, dogmatic or judicial, impressionistic or what you please, its actual worth is found in this: that it does help in various ways to stimulate the love of literature itself. It arouses our interest, it piques our curiosity, it excites our disapproval, it combats our prejudices, it reveals to us new facets as in a brilliant which already we admire. If it only leads us to think more of what we read, and to read more in order that we may think,—then its true function has been faithfully discharged.

And as to the appreciation of literature, you may approach it zoologically like Sainte-Beuve, or biologically like Taine, or in any way that you prefer. But the glorious fact about it is that you do not need come to it in any set and formal way, but that you plunge into it with gladness as a strong swimmer plunges into the waters of a summer sea. Political economy may be the dismal science, but literature is surely the joyous art. To derive pleasure from it one does not have to pass an entrance examination. Here is where it differs from the sciences. Before you can ascend into the hyperspaces of transcendental mathematics and play there like a kitten with a skein of silk, you must have learned to scorn delights and live laborious days. Before you can feel the joy of the biologist and work out a law according to which, after breeding white mice with black mice, and their offspring with various grey mice, you will have at last a litter composed of a definite number of grey and black and white mice and just one small yellow mouse,—before you can do this, you must have been mewed up with mice for many years. But with literature the case is very different. If you have felt much and experienced much, then you will receive the more. If you are still new to life, then literature will teach you what life means. But criticism, beyond a certain point, is not merely a hindrance. It is an impertinence. In Schopenhauer's words, it

busies itself with the clay and the colours and does not see the beauty of the vase. Take what view you will of the greatest works of genius. Interpret them as suits you best. What does it matter, for example, that Cervantes himself meant Don Quixote to be only a fantastic fool, the butt of everyone who meets him? We, on the contrary, are welcome to see in him an allegory of the Ideal struggling vainly against materialism. What does it matter that Shakespeare meant Shylock to appear only as a greedy, malignant, revengeful outcast, rightfully deprived in the end of both his ducats and his daughter? We may see him an infinitely pathetic, even tragic, figure, just as Heine saw him. Interpretation, understanding are free to all. One chooses gladly the open road, the brilliant sunshine, and the sapphire arch of heaven overhead. In literature, at least, we do not prefer to travel by the subway.

Emerson once wrote: "The only sin is limitation." There are probably some other sins; but, in our enjoyment of literature, surely the greatest sin is limitation. Here every mood is fully met. Here every wish is answered. Here one keeps the best of all good company. Criticism cannot make us feel the influence of that inextricable residuum, that "inexplicable monad," which lies in a rich individuality. For, after criticism has spoken its last word, and after analysis has reached the utmost limit of its power, there is only the beginning of what, for the want of a better name, we are accustomed to call genius. And you can no more analyse genius than you can express the splendour of God in volts and ohms.

If criticism is in reality becoming the "ultimate evolution, the final type of literature," then our civilization has reached the beginning of its end. It is turning Alexandrian or Byzantine. I wonder how often in the past men have felt that the world was growing old and grey, and

that its intellectual life was verging on extinction. Doubtless far back in Babylonia and Assyria and Egypt, they thought that decadence and exhaustion had begun. Nearly every age since then has experienced the same feeling. It is echoed in the lines of Tennyson written in his declining years:

Gone the cry of Forward! Forward! lost within a growing gloom;
Lost, or only heard in silence from the silence of a tomb,—

Half the marvels of my morning, triumphs over time and space,
Staled by frequency, shrunk by usage into commonest commonplace.

And the same thought was in the mind of Mr. Froude when he wrote these striking sentences:

“Who knows whereabouts we are in the duration of the race? Is humanity crawling out of the cradle, or tottering into the grave? Is it in the nursery, in the schoolroom, or in opening manhood? Who knows?”

Who, indeed? But when we look upon the past with all its limitations, its pettiness, and its particularism, and when we discern, as we think that we discern to-day, the dawning of a new and splendid era of humanity, with a fuller, freer recognition of essential oneness, why despond? Great events are still to happen; and to great events, literature always throbs responsively in new forms and with fresh founts of inspiration. Hence, the exultant words of Emerson, with their magnificent exaggeration, come to me as the voice of truth itself: “All literature is yet to be written. Poetry has scarce chanted its first song. The world is new, untried. Do not believe the past. I give to you the Universe to-day,—a virgin!”

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